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GEOLOGY.—*Laredo, a new name for a unit of Cook Mountain age in the Rio Grande region.*[1] JULIA GARDNER, U. S. Geological Survey.

I here propose the name Laredo for the part of the measured section of the Claiborne group that, in the report on the "Geology and ground-water resources of Webb County, Texas," by Lonsdale and Day, 1937,[2] is included under the name of Cook Mountain formation, and for all beds of equivalent age in the Rio Grande embayment. The area in which the name is to apply extends southwest from Frio, McMullen, and Live Oak Counties into Mexico. The Laredo formation is underlain by the Mount Selman formation, which in the upper part is dominantly clay with minor beds of sandstone and coal seams. It is overlain by the Yegua formation, which is predominantly clay and sandy clay with occasional oyster reefs.

Geologists working in south Texas have recognized for many years that the middle Eocene section differed in lithologic composition and in faunal assemblages from those displayed in central and eastern Texas. Partly through inertia and partly because it has seemed more profitable to recognize resemblances than differences, the name used to designate the upper part of the lower Claiborne in central and eastern Texas has been retained for the presumably equivalent portion of the south Texas section. However, the continued study of the section shown in the Rio Grande embayment has made increasingly inept the inclusion of the heavy sandstone section of south Texas under the name Cook Mountain formation. Our detailed knowledge rests largely upon the reports of Trowbridge[3] and that of Lonsdale and Day, to which reference has already been made. The composite section of Lonsdale and Day includes the beds lying between the top of the Mount Selman, about 5 miles above Laredo, to the base of

[1] Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Received May 3, 1938.

[2] LONSDALE, J. T., and DAY, J. R. *Geology and ground-water resources of Webb County, Texas.* U. S. Geol. Survey Water Supply Paper 778. 1937.

[3] TROWBRIDGE, A. C. *A geologic reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande.* U. S. Geol. Survey Prof. Paper 131-D. 1923.—*Tertiary and Quaternary geology of the lower Rio Grande region, Texas.* U. S. Geol. Survey Bull. 837. 1932.

the Yegua on the Laredo-Corpus Christi highway, 7.5 miles east of Laredo Post Office. The sections from the top of the Mount Selman on Sambarieto Creek, 5 miles north of Laredo, to that in Arroyo Chacon, about 2 miles south of Laredo Post Office, were continuous and were measured in great detail. Quoting from Lonsdale and Day, page 44:

> The thickness of the formation in the sections measured near Laredo is 630 feet. It is probably greater in the northern part of the county, and in wells east of the outcrop area the formation reaches a thickness of 875 feet. The dip is about 85 feet to the mile.

The beds include sands both soft and indurated, glauconitic sandstone, glauconitic marl and clay, and thin limestones commonly concretionary. In the Laredo district the sands and sandstones make up more than 50 percent of the formation, but farther north, in Webb County, the upper third of the formation includes more clay than sandstone. Fossil molluscan faunas are widespread both vertically and throughout the area of outcrop. A number of zones, each assemblage characterized by one or more dominant fossils, can be discriminated.

BOTANY.—*New grasses from Peiling Miao, Suiyuan Province, China.*[1] Y. L. KENG, National Central University, Chungking, China. (Communicated by AGNES CHASE.)

During July and August, 1935, the writer joined the Roerich Expedition to Inner Mongolia in search of drought-resistant plants which might be introduced for forage into the great Southwest of the United States. The Expedition camped at Temur Khada, Peiling Miao, Suiyuan Province, as the center of their collections. In this arid region the grasses are the most dominant plants forming the greater part of the forage on the steppe. There were about 50 species of grasses collected during that season, among them the following 6 species appear to be unpublished and are here described.

Cleistogenes foliosa Keng, sp. nov.

Perennis 25–40 cm alta, foliosa, caespites densos formans; culmus erectus, circ. 1 mm crassus; vaginae glabrae vel oribus pilosae, internodiis longiores vel raro inferiores breviores; ligula e annulo pilorum ciliatorum circ. 0.5 mm longorum constituta; laminae planae vel in sicco involutae, 3–8 cm longae, 1.5–2.5 mm latae, praesertim versus apicem subulato-involutum scaberulae; panicula angusta, inferne inclusa, 4–7 cm longa, ramis simplicibus, ad quemvis nodum solitariis, angulatis, ut axis communis scaberulis; pedicelli rhachi adpressi, 1.5–2.5 mm vel terminales 5–7 mm longi; spiculae 3–4-florae, 6–7 mm longae (aristam brevem excludentes), pallide virides, stramineae, vel

[1] Received April 7, 1938.

ad maturitatem pauludum purpureae; glumae tenues vel scariosae, plerumque angustae, acuminatae, 1-nerves, prima (interdum acuta vel obtusiuscula, enervi) 1.5–3 mm, secunda 3.5–4.5 mm longa; lemmata superne scaberula, breviter bidentata, 5-nervia, midnervo in aristam rectam scaberulam 1.5–3 mm longam producto, prope margines scariosos plus minusve pilosa, prima circ. 6 mm longa, callo pubescente; palea bidentata, angusta, glabra vel latera prope medium sparse pilosa; antherae 3, 2.2–2.5 mm longae rhachillae articula circ. 1 mm longa, versus apicem cupularem pubescens.

Culms densely tufted, simple, leafy, 25–40 cm tall, about 1 mm thick, usually entirely enclosed by the sheaths; sheaths glabrous or pilose at the mouth, longer or rarely the lower ones shorter than the internodes; ligule composed of a ring of hairs about 0.5 mm long; blades flat or involute when dry, 3–8 cm long, 1.5–2.5 mm wide, scaberulous especially towards the subulate-involute apex; panicle narrow, included below, 4–7 cm long, the branches simple, solitary, angular, scaberulous like the main axis; pedicels appressed to the rachis, 1.5–2.5 mm, or the terminal ones 5–7 mm long; spikelets 3–4-flowered, 6–7 mm long (excluding the short awn), pale green, stramineous or somewhat purplish at maturity; glumes thin or scarious, usually narrow, glabrous, the first 1.5–3 mm, the second 3.5–4.5 mm long, acuminate, 1-nerved (the first glume sometimes acute or obtusish, nerveless); lemmas scaberulous above, shortly bidentate, 5-nerved, the midnerve prolonged into a straight scaberulous awn 1.5–3 mm long, more or less pilose near the scarious margins, the callus pubescent, the first lemma about 6 mm long; palea narrow, 0.6–0.8 mm wide between the ciliolate keels, glabrous or the sides, sparsely pilose near the middle, the keels prolonged into a short mucros; anthers 3, 2.2–2.5 mm long; rachilla joint about 1 mm long, pubescent towards the cupular apex.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected on rocky slope, vicinity of Naran Obo, Peiling Miao, Suiyuan Province, August 21, 1935, by *Y. L. Keng no. 3538*, (*Roerich Exp. no. 886*). Other collections of this species are the following:

SUIYUAN: Peiling Miao: vicinity of Temur Khada, *Roerich Exp. 808, 814, 825* (*Keng 3460, 3466, 3477*); Payin Obo, vicinity of Olun-sumu, *Roerich Exp. 755* (*Keng 3407*); Madoni Ama, *Roerich Exp. 778* (*Keng 3430*).

This species is near *C. bulgarica* (Bornm.) Keng, from which it differs in having 3–4-flowered spikelets with narrower glumes and longer lemmas.

Cleistogenes mutica Keng, sp. nov.

Perennis 20–40 cm alta, caespites densos formans; culmus erectus, plurinodis, glaber, tenuis; vaginae glabrae vel oribus saepe villosae, inferiores aggregatae, superiores internodiis saepissime longiores, paniculae partem inferiorem attingentes vel amplectantes; ligula truncata, 0.5–0.8 mm longa, in pilos ciliatos superne divisa; laminae firmae 2–10 cm longae, 1–2 mm latae, scaberulae, planae vel versus apicem subulato-involutae; panicula diffusa, 4–8 cm longa, ramis simplicibus, puberulis, 1–2.5 cm longis; spiculae 3-10-florae, 4–10 mm longae, muticae, ad maturitatem pauludum purpureae; glumae acuminatae, saepissime scariosae, 1-nerves, inferior 2–3 mm, superior 3–4 mm longa; lemmata integra, 3-5-nervia, acuminata vel in mucronem minutum producta, in carina et prope margines plerumque adpresso-pubescentia, prima 3–4 mm longa, callo pubescente; palea 3–3.5 mm longa, in carina supra basin ciliata, versus apicem scaberula

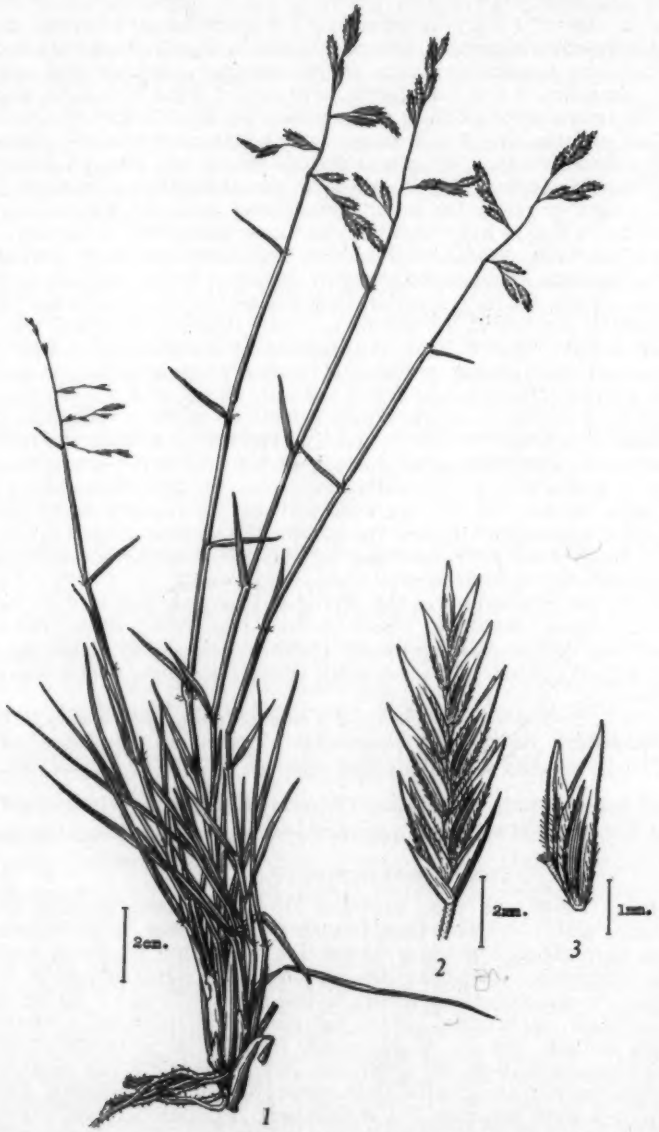


Fig. 1.—*Cleistogenes mutica* Keng. 1, habit; 2, spikelet; 3, floret. (Type)

vel fere leavis; antherae 1.5–2 mm longae, sufflavae vel purpureae; caryopsis (immatura) circ. 1.5 mm longa; rhachillae articula supra 1 mm longa, praesertim versus apicem cupularem pubescens.

Culms densely tufted, 20–40 cm tall, several-noded, enclosed by the sheaths or the internodes sometimes shortly exserted; sheaths glabrous or the mouth frequently villous, the lower aggregated and forming the thickened base of the culm; ligule truncate, 0.5–0.8 mm long, laciniate into hairs above; blades firm, 2–10 cm long, 1–2 mm wide, scaberulous or the lower surface nearly smooth towards the base, flat or subulate-involute towards the tip; panicle diffuse, 4–8 cm long, the branches simple, puberulent, 1–2.5 cm long; spikelets 3–10-flowered, 4–10 mm long, purplish at maturity; glumes acuminate, 1-nerved, usually scarious except the nerve, the first 2–3 mm, the second 3–4 mm long; lemmas entire, 3–5-nerved, acuminate or rarely the midnerve produced into a minute mucro, usually appressed-pubescent on the keel and near the margins, the first lemma 3–4 mm long, the callus pubescent; palea 3–3.5 mm long, the keels ciliate above the base, scaberulous or nearly smooth towards the apex; anthers 1.5–2 mm long, yellowish or purple; grain (immature) about 1.5 mm long; rachilla joint more than 1 mm long, pubescent especially towards the cupular apex.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected on sandy steppe between Peiling Miao and Shiretu Obo, Suiyuan Province, August 6, 1935, by *Y. L. Keng no. 3378* (*Roerich Exp. no. 726*). Other collections of this species are the following:

SUIYUAN: Olun-sumu, *Roerich Exp. 576* (*Keng 3231*); Darkhan-wang, *Roerich Exp. 798* (*Keng 3450*); vicinity of Temur Khada, *Roerich Exp. 807* (*Keng 3459*), *Keng 3562*; Shara Muren, *Roerich Exp. 848* (*Keng 3500*).

This species was misidentified as *C. chinensis* Keng[2] which is based on *Diplachne serotina* var. *chinensis* Maxim. Through the kindness of Dr. N. P. Avdulov, I received last spring one of Maximowicz's type plants and found that the species here described is distinguished by the awnless spikelets, longer glumes, and shorter lemmas. The spikelets differ also in having 3 to 10 florets, Maximowicz's plant examined having spikelets with 2 to 4 florets.

Puccinellia poaeoides Keng, sp. nov.

Perennis, caespitosa; innovationes intravaginales; culmus circ. 30 cm altus, 1.2–1.6 mm crassus, inferne geniculatus, 2–3-nodis, nodo supremo in circ. ¼ inferiore sito; vaginae firmae, laeves, glaucae vel basilares stramineae, suprema 8–12 cm longa, superiore internodio demum paullo breviore; ligula firma, rotunda vel truncata, 0.5–1 mm longa; laminae caulinae circ. 3, superiores breviores, 1.5–4 cm vel eae innovationum usque 8 cm longae, plerumque involutae, expandae 2–3.5 mm latae, glaucae, erectae, subter laeves, super valide nerves puberulentaeque; panicula aperta, 8–12 cm longa, ramis binis, tenuibus, patentibus, usque 6 cm longis, inferne nudis, superne spiculiferis et leviter flexuosis; pedicelli rhachi adpressi, scaberuli vel scabri, saepissime 1–5 mm (interdum subsessiles, circ. 0.5 mm) longi; spiculae stramineae, 4–6-florae, 5–7 mm longae; rhachillae articula tenuis, glabra, circ. 0.8 mm longa; glumae obtusae vel paullo acutiusculae, glabrae vel superne minute ciliolatae, prima 1.2–1.8 mm longa, 1-nervi, secunda circ.

[2] Sinensia 5 (1 and 2): 152. 1934.

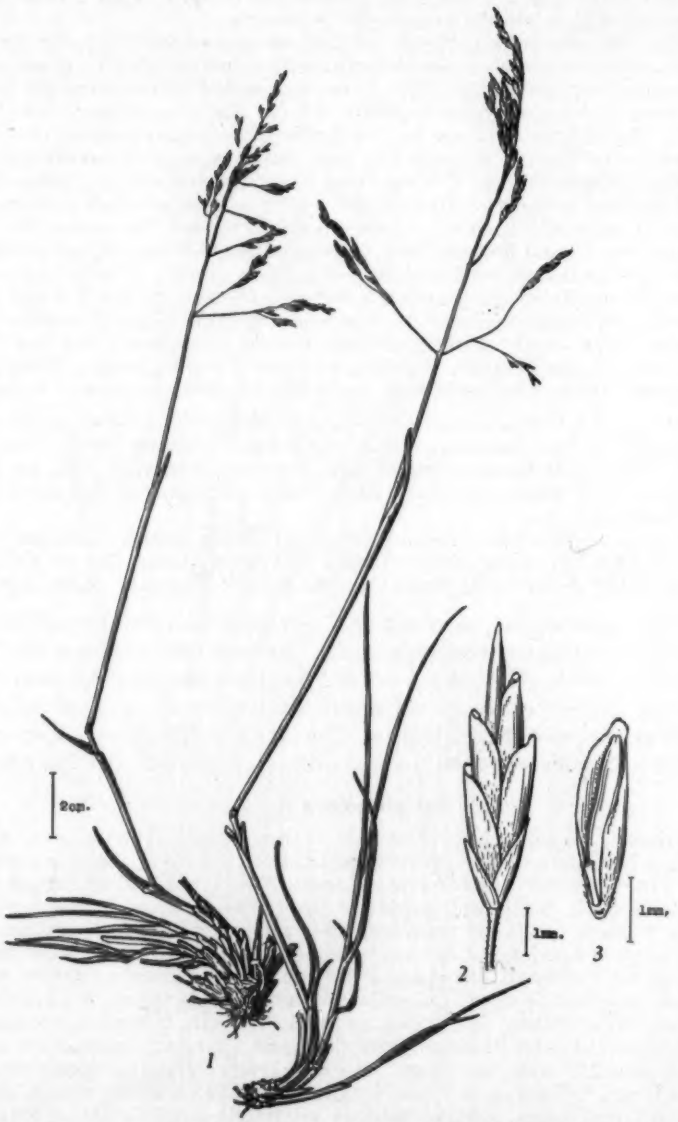


Fig. 2.—*Puccinellia poaeoides* Keng. 1, habit; 2, spikelet; 3, floret. (Type)

2 mm longa, inferne 3-nervi; lemmata obtusa, dorso rotunda, 2.5–3.5 mm longa, obscure 5-nervia, superne scariosa, inferne adpresso-pubescentia; palea lemmato paullo brevior, emarginata, carinis superne ciliolata; antherae pallidae, circ. 1.5 mm longae; caryopsis fusiformis, circ. 2 mm longa, ad maturitatem plumbea.

Perennial with intravaginal innovations; culms tufted, geniculate below, about 30 cm tall, 1.2–1.6 mm thick, 2–3-noded, the uppermost node situated about one-fourth from the base; sheaths firm, smooth, glaucous or the basal ones stramineous, the uppermost 8–12 cm long, the next finally a little shorter than the internodes; ligule firm, rounded or truncate, 0.5–1 mm long, decurrent; blades about 3 on the culm, the upper the shorter, 1.5–4 cm, or those of the innovations up to 8 cm long, usually involute, 2–3.5 mm wide when expanded, glaucous, erect, smooth beneath, strongly nerved and puberulent above; panicle open, 8–12 cm long, the branches 2-nate, slender, spreading up to 6 cm long, naked below, spikelet bearing and somewhat flexuous above, scaberulous or scabrous the appressed pedicels similar mostly 1–5 mm long (sometimes only 0.5 mm long); spikelets stramineous, 4–6-flowered, 5–7 mm long, the rachilla joint slender, glabrous, about 0.8 mm long; glumes obtuse or slightly acute, glabrous or minutely ciliolate above, the first 1.2–1.8 mm long, 1-nerved, the second about 2 mm long, 3-nerved below; lemmas obtuse, rounded on the back, 2.5–3.5 mm long, obscurely 5-nerved, scarious above, appressed-pubescent below; palea a little shorter than its lemma, emarginate, the keels ciliolate above; anthers pale, about 1.5 mm long; caryopsis fusiform, about 2 mm long, lead-colored when ripe.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected on steppe of alkali soil, Ashown Coop, about 5 miles northeast of Naran Obo, Peiling Miao, Suiyuan Province, August 8, 1935, by *Y. L. Keng no. 3395*, (*Roerich Exp. no. 743*).

This species is probably related to *Puccinellia jeholensis* Kitagawa,[3] from which it differs however, in having a smaller panicle and stramineous spikelets of 4–6 florets.

Puccinellia filiformis Keng, sp. nov.

Perennis, caespitosa; culmus 10–25 cm altus, 0.5–1 mm crassus, 2–3-nodis, nodo supremo a basi foliosa 3–7 cm remoto; vaginae striatae, glabrae, internodiis longiores vel superiores paullo breviores, suprema 2–9 cm longa (quam eius lamina longiore); ligula scariosa, 0.5–2 mm longa, ovata vel triangularis; laminae firmae, glabrae, 0.8–6 cm longae, saepissime involutae, filiformes, expandae 0.75–1 mm latae; panicula 2.5–9.5 cm longa, ramis 2–5-nis, erectis sed ad maturitatem patentibus vel reflexis, tenuibus interdum flexuosisque, scabris vel ad partem inferiorem nudum fere laevibus; pedicelli scabri, rhachi adpressi, 0.5–2 mm vel terminales 3–6 mm longi; spiculae pallide virides, 3–10-florae, 3–6 mm longae; glumae ovato-oblongae, prima 1 mm longa, 1-nervi, secunda 1.5 mm longa, inferne 3-nervi, obtusae (vel prima leviter acuta), glabrae vel marginibus superne minute ciliolatae; lemmata obovata, obtusa, scariosa et interdum superne brunnescentia, obscure inferne 5-nervia, prima circ. 2 mm longa, callo pubescente; palea lemma aequans sed angustior, emarginata, carinis superne minute scaberula;

[3] *Puccinellia jeholensis* Kitagawa, Ind. Fl. Jehol. **64**: 102. 1936.—"Prov. Hsing-an occid: Prope O-nyu-to (N.H.K. Oct. 2. 1933.—Typus); prope lacum Borden-hu (N.H.K. Sept. 30, 1933)."

Fig. 3.—*Puccinellia filiformis* Keng. 1, habit; 2, spikelet; 3, floret. (Type)

antherae 3, 0.5–0.7 mm longae, pallidae vel sufflavae; caryopsis fusiformis, 1.2 mm longa; rhachillae articula tenuis, glabra, circ. 0.5 mm longa.

Perennial; culms tufted, 10–25 cm tall, 0.5–1 mm thick, 2-3-noded, the uppermost node 3–7 cm above the leafy base; sheaths striate, glabrous, longer, or the upper ones a little shorter, than the internodes, the uppermost 2–9 cm long (longer than its blade); ligule scarious, 0.5–2 mm long, ovate or triangular; blades firm, glabrous, 0.8–6 cm long, mostly involute, filiform, 0.75–1 mm wide when expanded; panicle 2.5–9.5 cm long, the branches 2-5-nate, erect or from spreading to reflexed at maturity, slender, sometimes flexuous, scabrous or nearly smooth on the lower naked half; pedicels scabrous, appressed, 0.5–2 mm or the terminal ones 3–5 mm long; spikelets pale green, 3-10-flowered, 3–6 mm long; glumes ovate-oblong, the first 1 mm long, 1-nerved, the second 1.5 mm long, 3-nerved below, obtuse or the first somewhat acute, glabrous or the margins minutely ciliolate above; lemmas obovate, obtuse, scarious and somtimes brownish above, obscurely 5-nerved below, the callus puberulent, the first lemma about 2 mm long; palea equaling the lemma but narrower, notched at apex, the keels minutely scaberulous above; anthers 0.5–0.7 mm long, pale or yellowish; grain fusiform, 1.2 mm long; rachilla joint slender, glabrous, about 0.5 mm long.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected on the moist steppe by side of a river, Shara Muren, Suiyuan Province, August 16, 1935, by *Y. L. Keng no. 3511* (*Roerich Exp. no. 859*). Other collections of this species are the following:

SUIYUAN: Batu Khalkin Gol, vicinity of Temur Khada, Peiling Miao, *Roerich Exp. 805* (*Keng 3457*); Madoni Ama, Peiling Miao, *Roerich Exp. 535* (*Keng 3198* in part).

This species is near *Puccinellia Kobayashii* Ohwi,[4] which is, according to the original description, distinguished by the smaller lemmas (1.5–1.8 mm long) and flat blades.

Agropyron mongolicum Keng, sp. nov.

Perenne, caespitosum, ad basin vaginis emarcidis incrassatum; culmus 20–50 cm altus, 1–1.2 mm crassus, 1–3-nodis, glaber vel infra spicam pubescens, plerumque ad nodum supremum vel inferiorem geniculatus, nodo supremo in $\frac{1}{6}$–$\frac{3}{8}$ inferiore sito; vaginae arctae, glabrae, internodiis breviores, suprema 3.5–8 cm longa (quam eius lamina longiore); ligula circ. 0.5 mm longa, truncata, ciliolata; laminae firmae, involutae, 2.5–8 cm vel eae innovationum supra 10 cm longae, expandae 2–3 mm latae, durae, rectae vel falcatae, leviter glaucae, ad paginam superiorem puberulae; spica longe exserta, recta, 3.5–7 cm longa, 5–7 mm lata; rhacheos internodia 2–5 mm longa, pubescentia vel fere glabra; spiculae erectae vel adscendentes, lucide flavae, oblongo-lanceolatae vel rhombicae, 3–8-florae, 8–12 mm longae; gluma prima 4–5 mm, secunda 5–6 mm longa, ambae glabrae vel ad carinas leviter pilosulae, ovato-lanceolatae, pungentes vel aristato-acutae, lateralibus late scariosae, 3-nerves, nervis viridibus, validis; lemmata oblongo-lanceolata, glabra vel puberulo-scaberula; plerumque mucronata, prima 6–7 mm longa (mucronem 0.5–1 mm longum includente); palea lemma aequans vel in flore superiore excedens, emarginata, carinis minute scaberula;

[4] Act. Phyt. 7 Geob. 4 (1): 31. 1935.—"Hab. Manchuria: prope Dairen (M. Kobayashi n. 21)."

Fig. 4.—*Agropyron mongolicum* Keng. 1, habit; 2, part of the spike; floret. (Type)

antherae cremeae, 3 mm longae; caryopsis ellipsoidea, circ. 4 mm longa, rubido-brunnea; rhachillae articula incrassata, circ. 1 mm longa, minute puberula.

Perennial; culms tufted, thickened at the base with fibrillose sheaths, 20–50 cm tall, 1–1.2 mm thick, 1–3-noded, glabrous or pubescent below the spike, usually geniculate at the uppermost or the lower node, the uppermost node situated $\frac{1}{6}$–$\frac{2}{5}$ above the base; sheaths tight, glabrous, shorter than the internodes, the uppermost 3.5–8 cm long (longer than its blade); ligule about 0.5 mm long, truncate, ciliolate; blades firm, involute, 2.5–8 cm or those of the innovations more than 10 cm long, 2–3 mm wide when expanded, stiff, straight or falcate, somewhat glaucous, the upper surface puberulent; spike long-exserted, straight, 3.5–7 cm long, 5–7 mm wide, the rachis joint 2–5 mm long, pubescent or nearly glabrate; spikelets erect or ascending, light-yellow, oblong-lanceolate or rhombic, 3–8-flowered, 8–12 mm long; first glume 4–5 mm, second glume 5–6 mm long, both glabrous or the keel somewhat pilose, ovate-lanceolate, pungent or awn-pointed, 3-nerved, the nerves green, strong, the sides broadly scarious; lemmas oblong-lanceolate, glabrous or puberulent-scaberulous, usually mucronate, the first 6–7 mm long including the mucro, 0.5–1 mm long; palea equaling or in the upper florets exceeding the lemma, notched at the apex, the keels minutely scaberulous; anthers creamy, 3 mm long; caryopsis ellipsoid, about 4 mm long, reddish-brown; rachilla joint stout, about 1 mm long, minutely puberulent.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected on exposed sandy and rocky slope, Payin Obo, about 90 li northeast of Peiling Miao, Suiyuan Province, August 9, 1935, by *Y. L. Keng no. 3400* (*Roerich Exp. no. 748*). This species was also collected at Darkhan-wang, the same province, August 11, 1935, by *Y. L. Keng no. 3452* (*Roerich Exp. no. 800*), and from Shara Muren, August 15, 1935, by *Y. L. Keng no. 3501* (*Roerich Exp. no. 849*).

This is apparently a drought-resistant grass which may be used for forage. Although intermediate forms between it and *A. cristatum* (L.) Gaertn. are also found in this region, the above cited specimens are distinguished from *A. cristatum* by the relatively longer but narrower spikes and the pubescent or nearly glabrate rachis.

Stipa (§Lasiagrostis) **roerichii** Keng, sp. nov.

Culmi caespitosi, erecti, ubi veteres rigidi, 45–60 cm alti, 1.2–1.5 mm crassi, 3-nodes, nodo supremo prope vel infra medium eius sito; vaginae firmae, glabrae vel marginibus ciliolatae, internodiis longiores vel demum breviores; ligula scariosa, 0.5–1 mm longa, truncata vel pluri-partita; laminae firmae, erectae, setaceo-acuminatae, glaucae, 8–26 cm longae, 2–4 mm latae, planae vel sicco saepissime involutae, glabrae, praeter margines scaberulos laeves; panicula 12–25 cm longa, inferne inclusa vel demum exserta, ramis binis, tenuibus, scaberulis, erecto-adscendentibus vel ad maturitatem patentissimis, inferne nudis, supra medium aequaliter spiculiferis; spiculae 5–6.5 mm longae, lucide virides, pedicellis erectis puberulis 2–9 mm longis fultae; glumae spiculam aequans, subaequales vel prima quam secunda 0.5–1 mm brevior, oblongo-lanceolatae, 3-nerves, acutae, superne scariosae, glabrae vel minute puberulae; lemma circ. 5 mm longum, 3-nerve, omnino pubescens, callo pilis albis circ. 1 mm longis dense barbato; arista cum lemmato continua, 10–14 mm longa, superne scaberula, infra medium laxe

tortuosa puberulaque; palea angusta, 4 mm longa, 2-nervis dorso adpresso-pubescens; antherae lineares, 3–3.5 mm longae, apice nudae.

Culms tufted, erect, rigid when old, 45–60 cm tall, 1.2–1.5 mm thick, 3-noded, the uppermost node situated near or below the middle of the culm; sheaths firm, glabrous or the margins ciliolate, longer or eventually shorter than the internodes, the uppermost 9–15 cm long (longer than its blade); ligule scarious, 0.5–1 mm long, truncate or frequently split; blades firm, erect, setaceous-acuminate, glaucous, 8–26 cm long, 2–4 mm wide, flat or mostly involute when dry, glabrous, smooth except the scaberulous margins; panicle 12–15 cm long, included or finally exserted, the branches binate, slender, scaberulous, erect-ascending or nearly horizontal at maturity, naked below, evenly spikelet bearing above the middle, the pedicels erect, puberulent, 2–9 mm long; spikelets light green, 5–6.5 mm long; glumes equaling the spikelet, subequal or the first 0.5–1 mm shorter than the second, oblong-lanceolate, 3-nerved, acute, scarious above, glabrous or minutely puberulent; lemma about 5 mm long, 3-nerved, pubescent throughout, the callus 0.5 mm long, densely bearded with whitish hairs about 1 mm long; awns continuous with the lemma, 10–14 mm long, scaberulous above, loosely twisted and puberulent below the middle; palea narrow, 4 mm long, 2-nerved, dorsally appressed-pubescent; anthers linear, 3–3.5 mm long, naked at the apex.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected in the crevice of exposed rocks near the hill top, Temur Khada, Peiling Miao, Suiyuan Province, altitude, 1500 meters, July 26, 1935, by *Y. L. Keng no. 3181* (*Roerich Exp. no. 518*). A second collection of this species was made on a moist rocky slope of the same region, August 24, 1935, by *Y. L. Keng no. 3557* (*Roerich Exp. no. 905*).

This species is probably related to *Stipa sibirica* (L.) Lam. from which it differs, in its smaller size, narrower blades, shorter spikelets, and in its glabrous anthers which are not penicillate at the apex. The species is named in honor of Professor Nicholas de Roerich, a famous painter of Russia, who was the head of our expedition to Inner Mongolia during the summer of 1935.

BOTANY.—*New species of* Elytraria *from the West Indies and Peru.*[1]

E. C. Leonard, U. S. National Museum. (Communicated by William R. Maxon.)

The genus *Elytraria*, of the family Acanthaceae, is limited in the West Indies apparently to Cuba and Hispaniola. Hitherto botanists have referred plants from these two islands either to *E. imbricata* (Vahl) Pers., of which *E. squamosa* (Jacq.) Lindau is a synonym, or to *E. Shaferi* (P. Wils.) Leonard. However, *E. imbricata*, characterized by a pair of scarious teeth on the flower bracts, has not to my knowledge been found off the mainland of tropical America except on

[1] Published by permission of the Secretary of the Smithsonian Institution. Received May 2, 1938.

Trinidad and Tobago, which after all have a flora of continental affinity.

In a recent paper on *Elytraria*[2] I erroneously treated *E. tridentata* var. *Wrightii* Gomez as a synonym of *E. squamosa*, i. e. *E. imbricata*. A careful study of type material (*Wright* 3053), which I had not seen at that time, convinces me that it consists entirely of small depauperate plants of *E. Shaferi*.

It seems expedient to classify West Indian material of this genus as representing four rather closely related species, as distinguished in the following key.

KEY TO THE WEST INDIAN SPECIES

Bracts puberulent.

Leaves firm, usually pilose; margins of bracts floccose-ciliate; plants never proliferous ..... 1. *E. Shaferi.*

Leaves thin, glabrous or subglabrous; margins of bracts ciliolate; inflorescence often proliferous ..... 2. *E. prolifera.*

Bracts glabrous.

Leaf blades strongly crenate and rugose, firm, typically oblong-linear or narrowly oblong-obovate ..... 3. *E. crenata.*

Leaf blades entire or repand, rarely crenate, not rugose, thin, typically ovate ..... 4. *E. planifolia.*

1. ELYTRARIA SHAFERI (P. Wils.) Leonard, Journ. Wash. Acad. Sci. **24**: 446. 1934.

Elytraria tridentata var. *Wrightii* Gomez, Anal. Hist. Nat. Madrid **23**: 280. 1894.

Tubiflora Shaferi P. Wils. Mem. Torrey Club **16**: 111. 1920.

Acaulescent; leaves oblanceolate, 1 to 5 cm long, 0.5 to 1.3 cm wide, obtuse or rounded at apex, gradually narrowed at base to a short winged petiole, firm, crenate-dentate, deep green, more or less reticulate-veined, pilose, or glabrescent except costa and basal portion; peduncles up to 6 cm long, slender, clothed with appressed, imbricate, acute scales, these 3 mm long, 1 mm wide, ciliate, puberulent or glabrescent; spikes 1 to 2 cm long; bracts oblong-ovate, 3 to 4 mm long, 1.8 to 2 mm wide, obtuse or acutish at apex, floccose-ciliate, appressed-pilose within, puberulent without; bractlets lanceolate, 3.5 mm long, 0.5 mm wide, pubescent at apex; calyx segments oblong, 4 mm long, 1 to 1.5 mm wide, acute or rounded and aristate at apex, thin, pilose at tip, the anterior segment bidentate, the teeth triangular; flowers not seen; capsules 3.5 mm long, conic, glabrous.

TYPE LOCALITY: Pinelands, Sierra Nipe, near Woodfred, Oriente, Cuba.

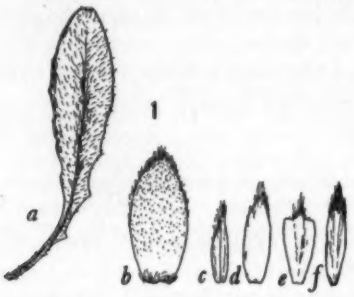
The following specimens have been examined:

CUBA: Sierra Nipe, *Shafer* 3562 (type at New York Botanical Garden). Palm barrens west of Santa Clara, *Smith, Hodgdon, Cheadle, & Taylor* 3157. Exact locality unknown, *Wright* 3053 (type of *Elytraria tridentata* var. *Wrightii* Gomez).

[2] Journ. Wash. Acad. Sci. **24**: 444. 1934.

2. Elytraria prolifera Leonard, sp. nov.

Herba acaulis, radicibus fibrosis, folia oblongo-obovata, apice rotundata, basin versus sensim angustata et in petiolum decurrentia, integra, repanda, membranacea, glabra vel costa parce pilosa; spicae solitariae, saepe radicosae; bracteae ovatae, apice acuminatae, puberulentae, ciliolatae; flores et capsulae desunt.



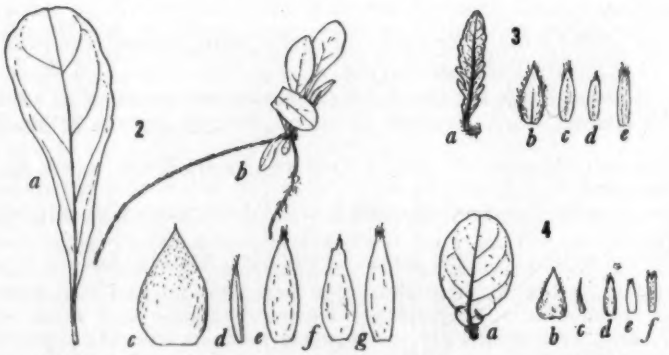


Fig. 1.—*Elytraria Shaferi* (P. Wils.) Leonard. *a*, leaf, nat size; *b*, bract; *c*, one of the lateral bractlets; *d*, posterior calyx segment; *e*, one of the lateral calyx segments; *f*, anterior calyx segment. (*b*, *c*, *d*, *e*, *f*, about 4 times nat. size.) Fig. 2.—*Elytraria prolifera* Leonard, sp. nov. *a*, leaf, nat. size; *b*, young plant replacing spike, nat. size; *c*, bract; *d*, one of the lateral bractlets; *e*, posterior calyx segment; *f*, one of the lateral calyx segments; *g*, anterior calyx segment. (*c*, *d*, *e*, f, *g*, about 6 times nat. size.) Fig. 3.—*Elytraria crenata* Leonard, sp. nov. *a*, leaf, nat. size; *b*, bract; *c*, posterior calyx segment; *d*, one of the lateral calyx segments; *e*, anterior calyx segment. (*b*, *c*, *d*, *e*, about 3 times nat. size.) Fig. 4.—*Elytraria planifolia* Leonard, sp. nov. *a*, leaf, nat. size; *b*, bract; *c*, one of the lateral bractlets; *d*, posterior calyx segment; *e*, one of the lateral calyx segments; *f*, anterior calyx segment. (*b*, *c*, *d*, *e*, *f*, about 3 times nat. size.)

An acaulescent herb, the crown densely pilose with brownish hairs about 1 mm long; leaf blades narrowly oblong-obovate, 2 to 6 cm long, rounded at apex, narrowed and decurrent on the petiole at base, entire or repand-dentate, very thin, glabrous or the costa sparingly pilose; petioles usually about 2 cm long, sparingly pilose; peduncles slender, up to 12 cm long, often

rooting and producing new plants at tips, the scales firm, ovate-lanceolate, 2.5 mm long, about 1 mm wide, acuminate, ciliolate, otherwise glabrous; spikes 10 to 12 mm long, the bracts ovate, 3.5 mm long, about 2 mm wide at base, acuminate, clasping the rachis by subhyaline auricles, firm, ciliolate, both surfaces puberulent; bractlets lanceolate, 3 mm long, the keel ciliate; calyx segments about 4 mm long, lanceolate, coriaceous, pubescent at tip, and anterior segment bidentate; flowers and fruit not seen.

Type in the U. S. National Herbarium, no. 1,413,065, collected on hillside at Ennery, Haiti, by E. L. Ekman (no. H. 8407). Ekman's no. H. 8877, collected at Pointe à Raquettes, Gonave Island, Haiti, and Eyerdam's no. 267 collected at Saline Madame Doisy, Gonave Island, are of this species.

Well marked by its proliferous habit and thin leaf blades. As in *E. Shaferi* the bracts are puberulent, but differ in being ciliolate with very minute hairs instead of floccose-ciliate.

3. Elytraria crenata Leonard, sp. nov.

Herba acaulis, radicibus fibrosis, folia breviter petiolata, lineari-oblonga vel oblongo-obovata, apice rotundata vel obtusa, basin versus sensim angustata, crenata, rugosa, utrinque pilosa; spicae solitariae; bracteae ovatae, glabrae floccoso-ciliatae; corolla alba; capsula conica, glabra.

An acaulescent herb, the leaves flat on the ground; leaf blades oblong-linear to narrowly oblong-obovate, 1 to 3 cm long, 3 to 5 mm wide, rounded or obtuse at apex, narrowed at base to a short petiole, firm, both surfaces strongly rugose, sparingly pilose or glabrescent above, densely pilose beneath with brownish hairs, the margins deeply crenate and ruffled; peduncles up to 4 cm long, the scales narrowly ovate, 2.5 to 3 mm long, about 0.75 mm wide, acuminate, ciliate, otherwise glabrous, closely appressed; spikes 1 to 1.5 cm long; scales subtending the flowers ovate, 3.5 mm long, 1.5 mm wide, acute, ciliate with whitish matted hairs about 0.5 mm long, otherwise glabrous, firm, faintly 3-nerved, the bractlets narrowly linear, 3 mm long, pilose; calyx segments oblong, about 3 mm long, 0.5 to 1 mm wide, the anterior segment bidentate; corolla white; capsule conic, 2 to 3 mm long, glabrous.

Type in the Herbarium of the New York Botanical Garden, collected on red soil, stony hillside of barren savanna southeast of Holguin, Province of Oriente, Cuba, November 1909, by J. A. Shafer (no. 2948). Ekman's no. 15559, collected on red soil of savannas in the vicinity of Nuevitas, Province of Camaguey, Cuba, is also of this species.

Distinct from *E. Shaferi* in its usually much smaller and relatively narrower, more deeply crinkled leaf blades and its glabrous bracts. The bracts of *E. Shaferi* are always more or less finely puberulent, in addition to the marginal hairs.

4. Elytraria planifolia Leonard, sp. nov.

Herba acaulis, radicibus fibrosis; folia ovata vel interdum anguste oblanceolata, apice rotundata, basin versus sensim angustata et in petiolum decurrentia, membranacea, repanda vel raro crenata, glabra vel costa venisque pilosa; spicae solitariae; bracteae ovatae vel lanceolatae, apice acuminatae, glabrae, ciliatae; corolla alba; capsula conica, glabra.

Acaulescent herb; leaf blades typically ovate (sometimes narrowly oblanceolate), 1 to 5 cm long, 3 to 15 mm wide, rounded at apex, narrowed and decurrent on petiole at base, thin, flat, entire or repand-dentate, rarely crenate, glabrous or costa and occasionally the lateral veins pilose; petioles 0.3 to 3 cm long, pilose; peduncles very slender, up to 20 cm long, the scales firm, subulate, about 2 mm long and 0.5 mm wide, ending in a small white

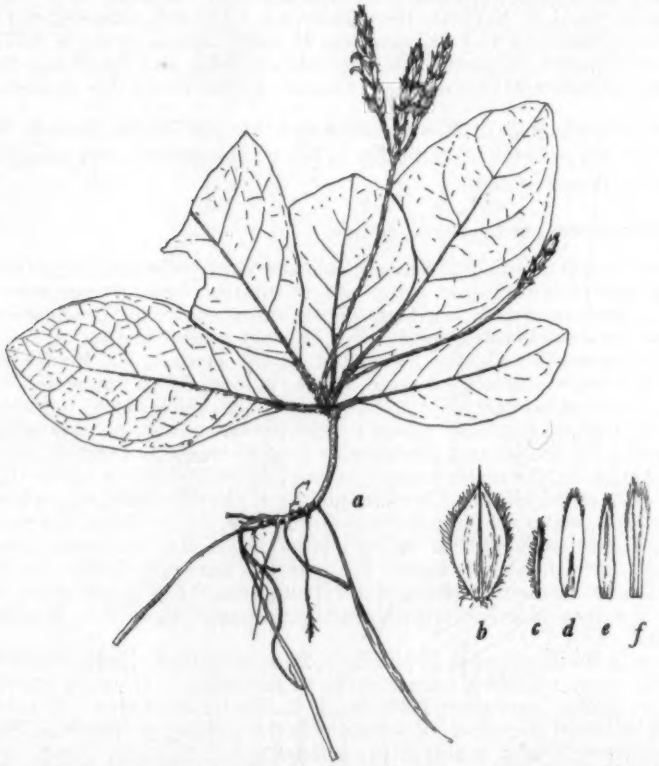


Fig. 5.—*Elytraria Klugii* Leonard, sp. nov. *a*, plant, half nat. size; *b*, bract; *c*, one of the lateral bractlets; *d*, posterior calyx segment; *e*, one of the lateral calyx segments; *f*, anterior calyx segment. (*b*, *c*, *d*, *e*, *f*, about 3 times nat. size.)

awn, spikes up to 1.5 cm long, usually about 1 cm long, the bracts ovate to lanceolate, 3 to 6 mm long, 1.5 to 2 mm wide, acuminate, ciliate, otherwise glabrous or nearly so; bractlets linear-lanceolate, 2.25 to 4 mm long, the keel ciliate; calyx segments slightly longer than the bractlets, the posterior narrowly oblong-ovate, the lateral narrowly lanceolate, the anterior linear and bidentate at apex, all pilose toward tip; corolla white; capsule conic, about 3 mm long, glabrous.

Type in the U. S. National Herbarium, no. 1,302,812, collected on steep hillside among shrubs, at Arroyo Machete, Sierra de Nipe, Province of Oriente, Cuba, Sept. 16, 1922, by E. L. Ekman (no. 15119).

The following additional specimens have been examined:

CUBA: Province of Santa Clara: Sagua, *Britton & Wilson* 385; city of Santa Clara, *Britton, Brit'on & Wilson* 6062; Sabana de San Marcos, *Leon* 9173; Placetas del Sur, *Leon & Roca* 8169. Province of Oriente: Between Taco and Nibujon, *Ekman* 3725.

5. Elytraria Klugii Leonard, sp. nov.

Herba acaulis vel caulescens, radicibus fusiformibus; folia petiolata, petiolo dense piloso, lamina elliptica, apice obtusa, basi acuta, repanda, glabra vel costa venisque hirsuta; spicae solitariae vel plures; bracteae ellipticae apice acuminatae aristatae, ciliatae; corolla alba; capsula glabra.

Caulescent or acaulescent herbs with fusiform roots; stems up to 3 cm long, retrorsely hirsute; leaf blades elliptic, 2 to 10 cm long, 1 to 5 cm wide, obtuse at apex, repand, rather thin, the costa and lateral veins (usually 5 pairs) hirsute, otherwise glabrous; petioles 1 to 1.5 cm long, densely pilose; peduncles up to 8 cm long, the scales triangular-ovate, 5 mm long, 4 mm wide at base, glabrous, ciliolate, closely clasping the peduncle; spikes 1 to 3 on each peduncle, 2 to 3 cm long, about 5 mm in diameter, bracts elliptic, 5 mm long, 3 mm wide, acuminate, ending in an awn about 1 mm long, 3-nerved (the nerves whitish), glabrous, the margins subhyaline, ciliate except at tip; bractlets linear, 3 mm long, 0.5 mm wide, acuminate, carinate, the keel and margins ciliate; calyx segments 4 mm long, thin, subhyaline, pilose at tip, the posterior segment oblong-elliptic, obtuse at apex, delicately nerved, the lateral segments lanceolate, barely 1 mm wide, acute, the anterior segment linear, 1 mm wide, bidentate at apex; corolla white, 5 to 6 mm long, glabrous; capsule 5 mm long, glabrous.

Type in the U. S. National Herbarium, no. 1,458,574, collected in forest along the Alto Río Huallaga, at Juan Jui, Department of San Martín, Peru, altitude 400–800 meters, June 1936, by G. Klug (no 4388).

A well-marked species apparently unrelated to any other South American member of the genus.

PALEOBOTANY.—*The stratigraphic significance of a southern element in later Tertiary floras of western America.*[1] DANIEL I. AXELROD, University of California. (Communicated by ROLAND W. BROWN.)

The succession of Tertiary[2] floras in western North America gives evidence of gradual modification and restriction. In response to a trend from warm, moist climate to cooler and drier conditions during the period, homogeneous forests, at the outset extensively distributed over regions of low relief, gave place to diversified units controlled by local topography and climate.[3] These changes in distribution and composition provide a basis for determining the age of Tertiary vegetation in western North America.[4]

[1] Received April 18, 1938.

[2] The Tertiary period includes the Eocene, Oligocene, Miocene, and Pliocene epochs.

[3] CHANEY, R. W. *The succession and distribution of Cenozoic floras around the northern Pacific basin*, in *Essays in Geobotany, in honor of William Albert Setchell.* Univ. Calif. Press, 55–87. 1936.

[4] CHANEY, R. W. *Plant distribution as a guide to age determination* Jour. Wash. Acad. Sci. **26** (8): 313–324. 1936.

TABLE 1.—SOUTHERN SPECIES IN THE PLIOCENE FLORAS OF THE WESTERN UNITED STATES

Fossil Species	Modern Equivalents	Nearest Modern Occurrence	Pliocene Occurrence		Oldest Fossil Occurrence
			Middle	Lower	Middle Miocene
Central California					
Celtis kansana Chaney & Elias	*C. reticulata*	Western Mohave area	Orinda		Tehachapi
Ilex sonomensis Dorf	*I. brandegeana*	Baja California		Sonoma	
Pinus kelloggi Webber	*P. cembroides*	San Rafael Mts.	Pinole		Tehachapi
Quercus bockeei Dorf	*Q. galeottii*	So. Mexico		Sonoma	
Quercus declinata Dorf	*Q. tomentella*	Insular So. Calif.		Sonoma	Tehachapi
Quercus pliopalmeri Axelrod	*Q. palmeri*	Interior So. Calif.	Orinda		Tehachapi
Quercus conveza Lesquereux	*Q. engelmanni*	Interior So. Calif.	Siesta		Tehachapi
Rhus prelaurina Axelrod	*R. laurina*	Coastal So. Calif.	Orinda		
Southern California					
Arbutus sp. Axelrod	*A. xalapensis*	Sonora	Mt. Eden		Tehachapi
Cupressus sp. Webber	*C. arizonica*	Arizona		Ricardo	Tehachapi
Palmoxylon mohavense Webber	?	Northern Mexico?		Ricardo	Tehachapi?
Robinia alexanderi Webber	*R. neo-mexicana*	Arizona		Ricardo	Tehachapi
Sapindus lamottei Axelrod	*S. drummondii*	Arizona	Mt. Eden		
Western Nevada					
Quercus turneri Knowlton	*Q. arizonica*	Arizona		Esmeralda	Tehachapi
Cupressus sp. (undescr.)	*C. arizonica*?	Arizona		Esmeralda	Tehachapi
Vaccinium ellipticum Berry	*Robinia*? *neo-mexicana*	Arizona		Esmeralda	Tehachapi
Southern High Plains					
Arctostaphylos prepungens Axelrod	*A. pungens*	Western Texas		Clarendon	
Condalia cf. *lycoides* Web. (= Phyllites sp. Chaney & Elias)	*C. lycoides*	Western Texas		Ogallala (Okl.)	Tehachapi
Diospyros pretexana Chaney & Elias	*D. texana*	Western Texas		Ogallala (Okl.)	
Sabal sp. (undescr.)	*S. texana*	Brownsville, Texas		Clarendon	
Ulmus moorei Chaney & Elias	*U. crassifolia*	Western Texas		Ogallala (Okl. & Kansas)	

Floras of the four epochs may be readily distinguished by this method, and the subdivisions of the three older epochs may also be satisfactorily recognized in most cases. But the task of placing a Pliocene flora in any definite part of the series has up to the present proved difficult or impossible. In the first place, the vegetation of the Pliocene has a more modern character than that of the preceding epochs, and has changed little down to the present. A second difficulty to detailed correlation is the highly localized development of Pliocene florules. They were an expression of micro-climates determined by slope exposure, altitude, position with respect to mountain ranges, and proximity to the ocean. On the other hand, Miocene and older floras inhabited regions of low or moderate relief where similar climatic conditions extended over wider areas. As a result, these floras were comparatively uniform for great distances and possessed many species in common. A third factor which has contributed to the difficulty of age determination of Pliocene florules is the absence of any climatically sensitive group of plants to afford a basis for correlation. Miocene floras, in contrast to those of the Pliocene, contain several distinct floral elements whose relative abundance in a flora assumes definite stratigraphic significance. For example, widespread occurrence of *Sequoia* on the Columbia Plateau in the early Miocene, and its poor representation there later in the epoch, suggests definite age differences within the series. Other Lower Miocene genera which are rare or absent by the end of the epoch are *Cercidiphyllum*, *Ginkgo*, and *Glyptostrobus* which make up a part of the Asiatic element, as well as *Carpinus*, *Castanea*, and *Tilia*, which are included in the broad-leaved deciduous group. While it is true that riparian species such as *Fraxinus*, *Platanus*, *Populus*, and *Salix*, occur consistently throughout most Pliocene floras in the western United States, these plants have small stratigraphic value, due to their lack of sensitivity to climatic change. Riparian species do not migrate any great distance under slightly altered climate, and hence afford little evidence of the climatic development characteristic of the Pliocene.

In the course of my studies of the Tertiary floras of southern California, an element has been found which appears to have originated in northern Mexico. This element has also been recorded at Lower Pliocene localities widely distributed to the north. Its reduction in numbers and range toward the close of the epoch appears to provide a basis for recognizing age differences. For some time it has been realized that certain species form a discordant unit in Pliocene floras. Instead of comprising part of the living flora at no great dis-

tance from the fossil locality, the modern equivalents of these species are now restricted far to the south. In his studies of the Pliocene floras of central California, Dorf[5] identified species of *Ilex*, *Quercus*, and *Rhus* related to plants now in Mexico and southern California. Chaney and Elias have pointed out the southern relationships of *Arctostaphylos*, *Bumelia*, *Celtis*, *Diospyros*, *Sabal*, and *Ulmus* as represented in the High Plains floras.[6] More recently, the writer has recognized a Mexican *Arbutus* in the Mount Eden flora of southern California, and has indicated the possibility of its origin in northern Mexico.[7]

The plants which form this austral element in the Pliocene floras of the western United States are listed in Table 1, together with data regarding their occurrence and that of their modern equivalents. Thirteen of the 21 species in this list first appear in the Middle Miocene Tehachapi flora of the western Mohave Desert.[8] This flora also includes such genera as *Diphysa*, *Dodonea*, *Ficus*, *Karwinskia*, *Lindleya*, *Pithecolobium*, *Robinia*, and *Sabal*, all of which are now restricted to the Southwest and to northern Mexico. Since the Tehachapi flora is considered to have had its origin in this interior southern area, it follows that the 13 Pliocene species occurring in it had a similar source. It also seems reasonable to suggest that the other 8 Pliocene species listed had a similar origin. Further collections in the earlier Miocene deposits of southeastern California and the Southwest, may be expected to add these to the list of Miocene species which first appeared in the western United States at its southern borders. The origin of this element in the south is emphasized by its rarity in the well-known floras of Miocene age to the north of the Tehachapi region. Before considering the Pliocene history of these southern plants, it is desirable to trace their distribution from the Tehachapi region northward.

More than 50 species comprise the Tehachapi flora, but only 8 have been recorded in Miocene floras farther north, as listed in Table 2. Of this list only *Quercus* (*Rhus*) *dispersa* and *Karwinskia* sp. are not also represented in the Pliocene to the north. Together with the 13 species mentioned in Table 1, there is a total of 19 species in the

[5] DORF, E. *Studies of the Pliocene palaeobotany of California.* Carnegie Inst. Wash. Pub. **412**: 30, 41–42, 100. 1930.

[6] CHANEY, R. W. and ELIAS, M. K. *Late Tertiary floras from the High Plains.* Carnegie Inst. Wash. Pub. **476** (1). 1936.

[7] AXELROD, D. I. *A Pliocene flora from the Mount Eden beds, southern California.* Carnegie Inst. Wash. Pub. **476** (3): 144–145. 1937.

[8] AXELROD, D. I. *A Miocene flora from the Tehachapi Pass region.* Proc. Geol. Soc. Amer. p. 394. 1937 (abstract).

Tehachapi flora which continued into the Pliocene. It is clear that the Tehachapi flora shows greater resemblance to Pliocene than to Miocene floras, for it has only 8 species in common with the Miocene at the north, and none of these is typically Miocene. From this relationship it may be concluded that the climatic conditions in southeastern California in Middle Miocene time resembled those of the Pliocene in northern regions. As judged from its composition, the Tehachapi flora inhabited a region characterized by an annual rainfall of approximately 20 inches, in contrast to nearly 35 inches in the Columbia Plateau at the same time. In addition, extremes of summer and winter temperature appear to have been much greater than in north-

TABLE 2.—TEHACHAPI SPECIES PREVIOUSLY RECORDED IN THE MIOCENE

Species	Miocene			
	Lower	Middle	Upper	Transitional
Cercocarpus antiquus Lesquereux			Blue Mts.	Table Mt.
Karwinskia sp.				Table Mt.
Platanus paucidentata Dorf		Monterey	Puente	Table Mt.
Pinus lindgreni Knowlton				Idaho
Quercus browni Brooks			Sucker Cr.	Idaho
Quercus conveza Lesquereux				Table Mt.
Quercus declinata Dorf				Idaho
Quercus (Rhus) dispersa Lesq.				Table Mt.

ern areas. The degree of continentality suggested by the flora is in harmony with its position in an interior area 800 miles south of the contemporaneous Miocene redwood flora.

There are several other records of southern species in Miocene floras to the north, but they appear to be related to an older migration. Berry has suggested a relationship between fossil oaks in the Latah and Grand Coulee floras and modern Mexican species.[9] Brown has indicated that *Cedrela pteraformis* (Berry) Brown from the Miocene of the Columbia Plateau may be of southern origin.[10] LaMotte has pointed out the resemblance of *Oreopanax conditi* LaMotte to a modern species in Central America.[11] Dorf has recorded a *Celastrus* from the late Miocene Idaho flora, which is related to a living species in the mountains of central Mexico.[12] It is of further interest that MacGinitie has recognized species of *Cedrela*, *Oreopanax*, and *Sapin-*

[9] BERRY, E. W. *A Miocene flora from Grand Coulee, Washington*, U. S. Geol. Survey Prof. Paper **170c**: 36. 1931; *Miocene plants from Idaho.* U. S. Geol. Survey Prof. Paper **185e**: 110. 1934.

[10] BROWN, R. W. *Miocene leaves, fruits, and seeds from Idaho, Oregon, and Washington.* Jour. Paleon. **9** (7): 585. 1935.

[11] LAMOTTE, R. S. *The Upper Cedarville flora of northwestern Nevada and adjacent California.* Carnegie Inst. Wash. Pub. **455**: 139–140. 1936.

[12] DORF, E. *A late Tertiary flora from southwestern Idaho.* Carnegie Inst. Wash. Pub. **476** (2): 120. 1936.

dus in the Florissant flora of Colorado which appear to have originated in the south.[13]

A consideration of the Eocene floras of western America[14] suggests that most of the species mentioned above may have moved northward from low latitudes during the migration which took place early in the Tertiary. Represented in these early Tertiary floras are many low latitude warm-temperate and subtropical plants including *Anona*. *Aralia*, *Calyptranthes*, *Cinnamomum*, *Drimys*, *Ficus*, and *Meliosma*, In addition, there are such genera as *Quercus*, *Rhamnus*, *Sophora*, and *Ulmus* whose modern representatives are now in the uplands of central and southern Mexico. It may be pointed out that an Eocene flora from the Mohave formation in the western Mohave Desert is dominated by such genera as *Celastrus*, *Hicoria*, *Juglans*, and *Myrica*, rather than by lowland genera such as characterized the windward slopes of the Pacific coast; the Mohave species also have their living representatives in central and southern Mexico. This suggests that all of these plants were migrating northward along cooler interior areas in Eocene time, and were not involved in the Middle Tertiary migration of the arid southern element.

The rarity or absence of this element in Miocene floras to the north, appears to be due to the fact that it was restricted to drier upland habitats along mountain ranges. From such situations there was little chance of leaves and other structures entering the fossil record. As lowland conditions became drier and warmer in the early Pliocene, and as the mesic forest was eliminated, these upland plants became established in lowland habitats where they entered accumulating deposits. This is clearly illustrated by the paleobotanical sequence in central California. Here the lowlands were occupied by a mesic *Taxodium-Nyssa* forest in Miocene time.[15] During the early Pliocene this flora was replaced by a more xeric type of vegetation. This included live oaks, shrubs, and riparian species which closely resemble plants still living in the region, together with species of *Celtis*, *Ilex*, *Pinus*, *Quercus*, and *Rhus*, which seem to have had a southern origin. That the upland flora in central California in late Miocene time contained certain of these "Pliocene" species is shown by the general character of the Table Mountain flora in the foothills of the central

[13] Oral communication, April 2, 1938.

[14] CHANEY, R. W. *The Goshen flora of west-central Oregon.* Carnegie Inst. Wash. Pub. **439**. 1933; SANBORN, E. I. *The Comstock flora of west-central Oregon.* Carnegie Inst. Wash. Pub. **465** (1). 1935; POTSBURY, S. S. *The La Porte flora of Plumas County California.* Ibid., pt. 2. 1935.

[15] CONDIT, C. *The San Pablo flora of west-central California.* Carnegie Inst. Wash. Pub. **476** (5). 1938.

Sierra Nevada.[16] Represented in it are 6 species which have been recorded in the Pliocene of central California, and all of these have modern equivalents in the region today. These are listed below, along with their modern representatives.

TABLE MOUNTAIN SPECIES RECORDED IN THE PLIOCENE

Table Mountain Species	Modern Representatives
Arbutus matthesii Chaney	*A. menziesii*
Cercocarpus antiquus Lesquereux	*C. betuloides*
Platanus dissecta Lesquereux	*P. racemosa*
Quercus browni Brooks	*Q. chrysolepis*
Salix californica Lesquereux	*S. lasiolepis*
Umbellularia sp.	*U. californica*

In addition to these, there are other California species in the Table Mountain flora which have not been recorded in Pliocene deposits in central California: *Cornus ovalis* Lesquereux, and *Quercus* (*Rhus*) *dispersa* Lesquereux. Also contained in the flora are plants whose modern representatives are now limited farther south in present distribution: *Arbutus idahoensis* (Knowlton)Brown (in the Southwest and northern Mexico), *Karwinskia sp.* (in northern Mexico), and *Quercus convexa* Lesquereux (in interior southern California and the Southwest). It seems clear that the drier and warmer conditions of the early Pliocene shifted these species, which in late Miocene time had lived in drier uplands, into lowland habitats where they could enter accumulating deposits.

The later Pliocene floras in central California show indications of cooler and moister climate, and this is in harmony with the approaching Pleistocene epoch. The redwood forest, restricted in distribution during the Lower Pliocene, gradually extended its range in coast-central California. It was at this time that the southern element was limited to the south, for it has not been recorded in the late Middle or Upper Pliocene floras of central California. The southern plants represented in early Pliocene floras, therefore have stratigraphic value. They are distinctive in these floras whose other constituents are related to modern vegetation at no great distance from the fossil locality. Unlike the dominant riparian element, they are responsive to climatic change. Regularly present in early Pliocene floras, they disappeared to the north in the later portion of the epoch due to the cooler and moister conditions.

[16] LESQUEREUX, LEO. *Report on the fossil plants of the auriferous gravels deposits of the Sierra Nevada.* Mus. Comp. Zool. **6** (2). 1878; KNOWLTON, F. H. *Flora of the auriferous gravels of California.* U. S. Geol. Survey Prof. Paper **73**: 57–64. 1911; CHANEY, R. W. *The Mascall flora—its distribution and climatic relation.* Carnegie Inst. Wash. Pub. **349** (2).

Taking into account the general climatic trend from warm and dry to cooler and moister conditions during the Pliocene, and considering the occurrence of these floras with respect to mountain ranges, proximity to the ocean, latitude, and botanical provinces, the following general floral succession in the Pliocene of California may be indicated:

Upper Pliocene floras.—(1) Southern element absent in central California, and possibly in southern California; (2) species closely related to modern California plants still living near at hand; (3) species related to other California plants now limited to cooler habitats.

Middle Pliocene floras.—(1) Southern element with living representatives not as far south in present distribution as those of the Lower Pliocene; (2) plants resembling modern vegetation growing in the same general region.

Lower Pliocene floras.—(1) Southern element well developed, with modern descendants now mostly limited to Mexico and the Southwest; (2) species whose living representatives still exist at no great distance from the fossil locality.

Note.—The gradual reduction and elimination of the northern Miocene element from Pliocene floras may serve as a further basis for determining their position in the Pliocene when there are more floras known from central California and adjacent areas.

In addition to their California occurrence, southern plants are also represented in early Pliocene floras in two other regions in the western United States—in the Esmeralda flora of west-central Nevada[17] and in the Ogallala formation of Beaver County, Oklahoma, and near Clarendon, northern Texas.[18] The floristic relationships in these areas are not as clear as they are in California, where a greater number of Pliocene floras are available.

Additional collections must be obtained before the Esmeralda flora can be thoroughly analyzed. This is no place to evaluate the determinations suggested for all the species in the flora, but several suggestions are pertinent to the present discussion. The oak, *Quercus turneri* Knowlton, is certainly a southern species in its modern relationships, and shows resemblance to the living *Q. arizonica;* in addition, one of the species figured as *Cinchonidium? turneri* Knowlton[19] is assignable to *Q. turneri.* The oak leaf figured as *Quercus simulata* var. *truncata* Berry resembles the foliage of several modern oaks of northern Mexico, but is too poorly illustrated to suggest a definite relationship. The ovate leaf determined as *Vaccinium ellipticum* Berry

[17] KNOWLTON, F. H. *Fossil plants of the Esmeralda formation.* U. S. Geol. Survey 19th Ann. Rept. pt. 2, 209–220. 1900; BERRY, E. W. *The flora of the Esmeralda formation in western Nevada.* Proc. U. S. Nat. Mus. 72 (23). 1928.

[18] CHANEY, R. W. and ELIAS, M. K. *Late Tertiary floras from the High Plains.* Carnegie Inst. Wash. Pub. 476 (1). 1936.

[19] KNOWLTON, F. H. op. cit., pl. 30, fig. 11. 1900.

resembles the leaflets of several leguminous genera which are abundant throughout the Southwest and northern Mexico, and cannot be separated from the ovate leaflets of *Robinia neo-mexicana*. In addition to these leaf impressions, wood of *Cupressus* has been reported from the Esmeralda formation.[20] This genus is absent from Nevada today and is interpreted as a member of the southern element. Perhaps it is the Pliocene equivalent of the modern *C. arizonica*, a species with equivalents in both the Ricardo and Tehachapi floras.

There is a southern element in the Esmeralda flora, but a lower percentage of southern species are in it as compared with the Ricardo 200 miles farther south. This is explainable on the basis of the occurrence of the Esmeralda flora in a different climatic and floristic area where more of the northern genera (*Cercis*, *Trapa*) had survived.

Several florules have recently been described from the Ogallala formation of Nebraska, Kansas, Oklahoma, and northern Texas. It has been possible to identify southern plants in them and, as might be expected, the southernmost floras show a closer resemblance to vegetation farther south. The Clarendon florule of northern Texas is of interest because it is distinct from the other floras of the High Plains. It contains seeds of a *Sabal* palm, apparently representing the Pliocene equivalent of the modern *S. texana*, fruits of *Arctostaphylos* resembling the living *A. pungens*, and wood of *Fraxinus*. The Clarendon assemblage clearly suggests warmer and drier conditions than existed in the areas to the north. The distinctness of the Clarendon from the Beaver County flora 135 miles farther north, shows that they are not related, for its affinities are to the south rather than to the east, from which area the Beaver County flora derived several of its species.

The following species from the Lower Pliocene Beaver County flora of Oklahoma have also been recorded in the Middle Miocene Tehachapi flora, 1200 miles to the west: *Celtis kansana*, *Condalia* cf. *lycoides* (=*Phyllites* sp.), *Populus lamottei*, *Salix coalingensis*, *Typha lesquereuxi* and *Bumelia florissanti*. Disregarding the cat-tail and willow, a consideration of the modern distribution of the remaining species, as well as their presence in the Tehachapi flora, suggests that they represent an element which was developing in the Southwest and northern Mexico during the Middle Tertiary. To this group may perhaps be added the *Sapindus* and *Diospyros* of the Beaver County flora.

[20] GIANELLA, V. P. and WHEELER, H. E. *Tertiary gold-bearing fossil wood in Nevada*. Proc. Geol. Soc. Amer. p. 301. 1936 (abstract).

Condalia, *Diospyros*, and *Ulmus* represent the southern element in this flora, for their modern descendants are now in southwestern Texas. In addition, there is a legume[21] represented in the flora whose general shape, venation, and thickened petiole suggests an affinity with several arborescent genera now in the Southwest and northern Mexico. A more complete evaluation of the southern element in this area awaits the discovery of additional florules. It is believed that their recognition in early Pliocene floras of the southern High Plains may have stratigraphic value. As in California, a late Pliocene flora in this region would be expected to show the indications of a cooler and moister climate, and hence an absence of southern species.

Summary.—A distinct group of plants whose modern descendants are restricted southward, has been identified in Pliocene floras whose dominant element resembles living vegetation near at hand. A study of the Miocene floras in the western United States, and especially the middle Miocene Tehachapi flora, shows that this austral element had its origin in the Southwest and northern Mexico. These plants migrated northward along drier upland habitats during the Miocene and entered lowland deposits to the north in great abundance in early Pliocene time, when lowland conditions became drier and warmer. These species disappeared from areas of their former distribution in the north by the later Pliocene, in response to the lowered temperatures and increased rainfall which preceded the Pleistocene. Present evidence suggests that the occurrence of this southern element in a northern Pliocene flora establishes its early Pliocene age.

[21] CHANEY, R. W. and ELIAS, M. K. op. cit. 1936. The leaf figured as *Diospyros pretexana* Chaney and Elias, pl. 7, fig. 8, is considered to be a legume.

PALEOBOTANY.—*Protophycean Algae in the Ordovician of Nevada.*[1] CHARLES W. MERRIAM, Cornell University, and LYMAN H. DAUGHERTY, San Jose State College, California. (Communicated by C. LEWIS GAZIN.)

During the progress of stratigraphic work in the Roberts Mountains of central Nevada under a grant from the Penrose Fund of the Geological Society of America, a nodule-bearing horizon was encountered in bituminous graptolite shales of Ordovician age. Thin-sections of the nodular bodies disclosed a variety of organic remains among whch are microscopic algal aggregates showing original cellular structure.

The exposures which yielded the nodules lie slightly over three

[1] Received May 13, 1938.

miles east of the summit of Roberts Creek Mountain (Roberts Mountains quadrangle), on the east side of Vinini Creek canyon and about seven-tenths of a mile northwest of the canyon mouth. The nodules are most abundant in the wall of an old tunnel driven eastward on the east side of the canyon. The entire outcrop of the graptolitic shale is extensive, occupying several square miles along Vinini Creek. The shales in the vicinity of the tunnel are finely laminated and black when fresh, but weather to very light gray tones. The sediments contain a great deal of bituminous matter. When heated in a Bunsen flame they burn readily and yield a tarry odor. Graptolite rhabdosomes are very abundant and unusually well preserved. The genera recognized include *Climacograptus*, *Diplograptus*, and *Glossograptus*. At Garden Pass (formerly called Summit, Nevada), five and one half miles southeast of the tunnel locality another graptolite fauna is found. This assemblage has been discussed by Gurley,[2] Ruedemann[3] and Kirk[4] and is regarded by the last author as early Chazyan. In the fauna Gurley reports *Phyllograptus*, and *Didymograptus;* these have not been recognized in the Vinini Creek locality which may represent a somewhat higher horizon.

In addition to plant remains the nodules themselves contain much undistorted and apparently little altered graptolitic material such as spines and entire siculae. Several genera of radiolaria are also present.

The nodules are small, averaging the size of walnuts. They occur in definite layers, are distributed parallel to the bedding and are disposed in such manner that the contiguous laminae of the shale seem to pass around rather than into the small rounded bodies. Evidently a good deal of compaction has taken place subsequent to formation and induration of the nodules. They do not have the appearance of wholly concretionary segregations of mineral matter forming long after deposition of the surrounding muds.

The nodules possess an outer coating of black tarry material. Under the microscope in thin-section this is seen to be of deep golden brown color and is laminated concentrically. It may have a thickness of at least one and a half millimeters. The bodies are impregnated throughout with bituminous matter having a similar golden brown color. While the masses have not been studied mineralogically they are known to contain a moderate amount of pyrite. Only a small proportion of the substance was dissolved on prolonged

[2] GURLEY, R. R. Jour. Geol. **4**: 294–302. 1896.
[3] RUEDEMANN, R. *Graptolites of New York*, Pt. 2. New York State Museum Memoir No. **2**: 89, 382, 383, 440. 1908.
[4] KIRK, E. Am. Jour. Sci. **26**: 31. 1933.

treatment with dilute hydrochloric acid, indicating a limited percentage of carbonate. Tests for phosphate gave but a slight trace.

The minute algae occur as colonies of cells, frequently forming almost perfect spheres, though in the largest individuals they may be slightly flattened and appear oblong in section. The colonies vary in

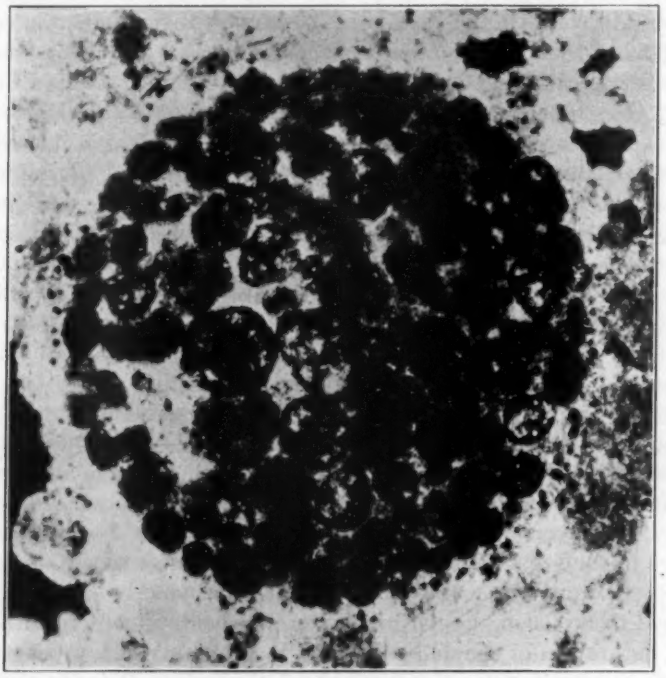


Fig. 1.—Photophycean algae, Ordovician, Roberts Mountains, Nevada. Spherical colony in thin-section, ×170 diameters. Occur in bituminous nodules resembling small coal balls.

diameter from 117 microns to 770 microns. There is evidently some differentiation of cells within the spherical groups. Individual cells are spherical to slightly angulated and range from 18 microns to 45 microns in diameter. Most of the larger clearly defined units lie well within the colony, while those on the outer border are inclined to be the smaller ones.

Whether the forms represent spore capsules or mature individual algal colonies has not been determined. Among described fossil algae they possess some of the characters of *Gloeocapsomorpha* from the

Ordovician Kukersite deposits of Esthonia. This interesting plant form played an important role in formation of the Kukersite, a variable Ordovician shaly sediment containing a high percentage of sapropelic debris. (Lindenbein, op. cit., pp. 381–382.) The Kukersite bears remains of trilobites, bryozoa and brachiopods, evidence that conditions may have been suitable for benthonic life. Lindenbein has reached the conclusion that *Gloeocapsomorpha* was itself a bottom-dwelling rather than a planktonic type. In the case of the Nevada graptolite shales the fauna is that of a "pure graptolite shale,"[5] all of the animal remains representing types which were in all probability members of the plankton (graptolites, radiolaria, small neotremate brachiopods with horny or phosphatic shells).

Gleocapsomorpha has been studied by Zalessky[6] and by Lindenbein.[7] Zalessky compares the form with the living blue-green alga *Gloeocapsa*. In the fossil *Gloeocapsomorpha* the individual cells are more or less irregular in form, are of yellowish color and occur as aggregates of varying shape within a supposed mucilaginous matrix. According to Lindenbein the cells ("cellules") have diameters ranging from 2 to 10 microns, while the colonies ("thalles") rarely exceed 0.1 millimeter.

The Nevada form appears to differ from the Esthonian type in the clearly spherical shape of many colonies and in the much greater number of cellular elements. The Esthonian form frequently shows an irregularly radiate arrangement of the less numerous cellular units in the individual colony or thallus and does not exhibit the peripheral layer of smaller cells, which last appears to be a characteristic of the Nevada genus.

For want of more specific terminology the harmless general term Protophyceae, applied to the ancient *Gloeocapsomorpha* by Lindenbein is adopted provisionally for the Nevada form figured herein.

It is likely that the small alga of the graptolite deposits constituted an important element in the Ordovician planktonic marine algal flora and may have been the source of much of the organic matter in the shales. A record of morphological character with preservation of such delicate structure would be expected only where deposition went on in relatively quiet waters below wave and violent current action. It is not, however, implied that these partially sapropelic muds were

[5] RUEDEMANN, R. Jour. Pal. 9 (1): 83. 1935.
[6] ZALESSKY, M. D. Soc. Paleont. Russie, for November. 1918.
[7] LINDENBEIN, H. A. R. Archieves Sciences Physiques et Naturelles, 5th periode 3: 393, figs. 1, 2. 1921.—Supplement to above: Compte Rendu des Seances, Société de Physique et D'Histoire Naturelle 38 (2): 60–63.

of bathyal or abyssal origin. In any case the algae and radiolaria inhabited the photic zone, but in view of presumed allochthanous origin of the organic matter, no clear-cut case can be made here for shallow water (neritic) accumulation of the shales.

The character of the nodules and unusual preservation of their organic contents calls to mind the remarkable coal balls of the Carboniferous, though processes involved in formation of the latter may be quite different.

ZOOLOGY.—*Two new species of amphipod crustaceans from the east coast of the United States.*[1] CLARENCE R. SHOEMAKER, United States National Museum. (Communicated by MARY J. RATHBUN.)

In November, 1937, a collection of amphipods taken at the Isles of Shoals, New Hampshire, by Mr. James A. Williams, was sent by him to the U. S. National Museum for identification. The collection for the most part contained only well known New England forms, but two, *Pontharpinia epistoma* and *Gammarus greenfieldi*, were recognized as being new to science. A number of specimens of *Pontharpinia epistoma* are in the National Museum collection, but these whenever identified, had been assigned to *Paraphoxus spinosus* Holmes, which they superficially much resemble. *Gammarus greenfieldi* is a very abundant littoral form occurring on the coast of Massachusetts and extending northward at least as far as Frenchmans Bay, Maine. It is surprising that such a conspicuous common littoral New England form should have remained unnoticed for so long a time.

Pontharpinia epistoma n. sp. Fig. 1

Diagnosis.—Gnathopods with sixth joint distally very broad and palms only slightly oblique. Fourth side-plate with hind excavation very shallow. Fifth peraeopod with hind margin of second joint plainly serrate. Third metasome segment with lower margin evenly convex and with a scarcely perceptible hind angle, hind margin with only a few long, closely set spines on lower part, above which it is convex.

Male.—Head, rostrum reaching to about the middle of the second peduncular joint of antenna 1, apex broadly rounding. Eye large, oval, brownish, Antenna 1, first and second peduncular joints equal in length, third joint very short; flagellum shorter than peduncle and composed of about nine joints which bear calceoli; accessory flagellum not much shorter than the primary and composed of about eight joints. Antenna 2 as long as the entire body, fourth and fifth peduncular joints equal in length; flagellum very long and slender and bearing a calceolus on every other joint. Epistome project-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received April 20, 1938.

ing forward, prominent, conical, and rather sharply pointed. In many specimens the epistome is not so prominent as in the specimen figured. Mandible with apparently five spines in spine-row; second and third joints of palp about equal in length. Maxilla 1, inner plate very well developed, with perhaps three short apical spines and a few marginal setules; outer plate with eleven spine-teeth which may be slightly serrate; palp two-jointed and bearing six apical spines. Maxilla 2 with inner and outer plates about equal in size and shape. Maxillipeds, inner plate broader than outer and bearing distally one spine and several spinules; outer plate short, reaching to about the end of first joint of palp and bearing a few spines on inner margin; fourth joint of palp very slender, curved and bearing a minute spinule on inner margin near apex.

Side-plates 1 to 4 bearing a few setae on lower margin, fourth very slightly excavate behind, fifth bilobed with front lobe shallower than hind lobe. Gnathopods about alike in size and shape; sixth joint rather short, and widening very much distally; palm only slightly oblique, and defined by a rounding projection of the hind margin of sixth joint. First and second peraeopods about alike in size and shape; the form and armature of these, as also of peraeopod 3, 4, and 5, are accurately shown in the accompanying figures of these appendages.

Pleon segment 1 rather evenly rounding below. Segment 2 broader below than either 1 or 3, a row of plumose setae near lower margin which is slightly concave toward the rear margin. Segment 3 with very slight lower hind angle, lower margin convex and bearing a row of slender marginal spines above which in the largest specimens are a few scattered spines, lower hind margin straight for a short distance and bearing a row of long slender closely-set spines above which the margin is convex. This hind margin is subject to considerable variation; in some specimens the convexity is very pronounced, while in others it is scarcely perceptible. Urosome slender. Uropods slender and rather sparsely spinose; but in the largest specimens they are stouter and more spinose. Uropod 1, peduncle bearing a few spines on the upper inner and outer margins, and a conspicuous spine on the inside distal end; outer ramus with three marginal spines and inner with two above and one slender spine projecting down from lower margin. In the largest specimens there are fewer peduncular spines, the large inside spine is absent and the spines of the rami are grouped closer together and are nearer the peduncle. Uropod 2, peduncle with a few marginal spines; outer ramus with two marginal spines and inner with one. In the largest specimens the peduncular spines are longer and the two or three proximal ones are conspicuously long and slender, the outer ramus with three spines and the inner with two. The spination of the pleon segments and the uropods is thus seen to vary with age, and even in the largest specimens the number of spines is not constant. Telson bearing two setae on either lateral margin, and two small spines on the apex of either lobe. Length of the largest males about 6 mm.

Type.—A male specimen taken by the U. S. Fisheries steamer *Albatross* at the surface off Block Island, Rhode Island, July 8, 1883, U. S. Nat. Mus. no. 75671.

Female.—The female is stouter and much broader than the male. The eyes are small, nearly round, and brownish. Antenna 2 not much longer than 1. The remaining appendages are very much like those of the male, except the third uropods, which show the sexual modification usual in the genus *Pontharpinia*. Uropod 3 of the female is shown in fig. *1 r*. Length of the largest females about 7 mm.

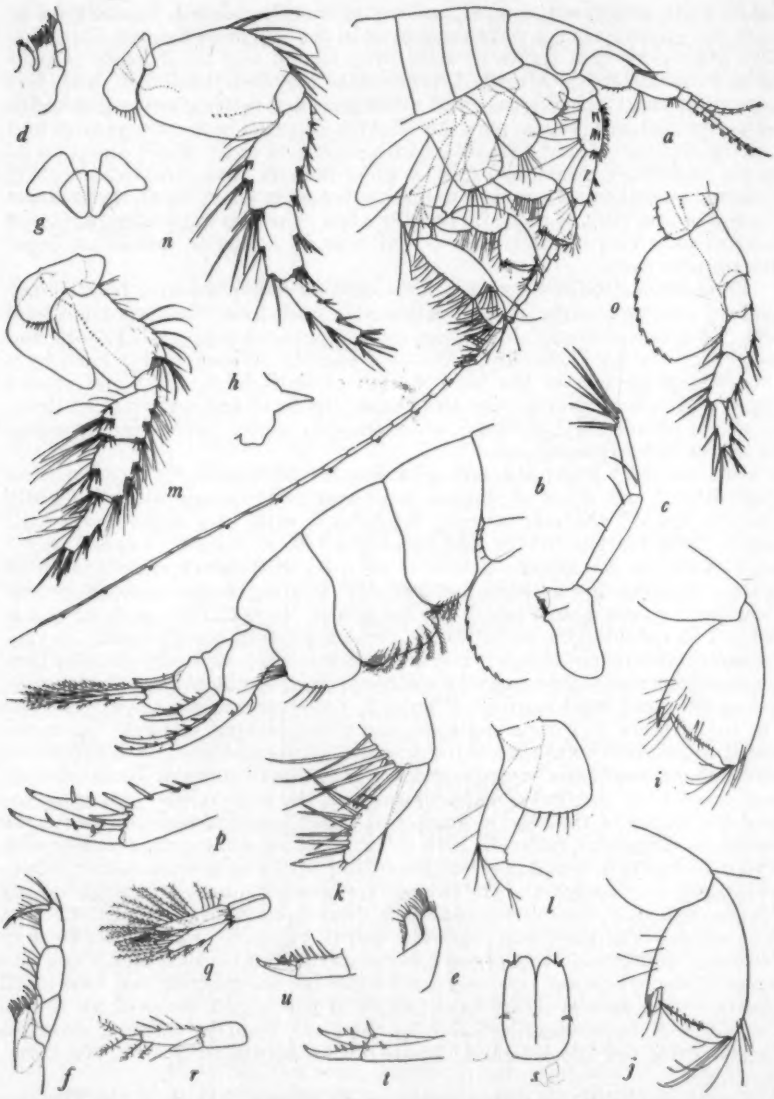


Fig. 1.—*Pontharpinia epistoma*, new species, male. *a*, Anterior end; *b*, posterior end; *c*, mandible; *d*, maxilla 1; *e*, maxilla 2; *f*, maxilliped; *g*, lower lip; *h*, epistome and upper lip; *i*, *j*, gnathopods 1 and 2; *k*, end of peraeopod 1; *l*, peraeopod 2; *m*, *n*, *o*, peraeopods 3, 4, and 5; *p*, uropod 1, inside; *q*, uropod 3; *r*, uropod 3, female; *s*, telson; *t*, *u*, uropods 1 and 2 of a larger male.

This species has been confused with Holmes' species *Paraphoxus spinosus* which it superficially resembles. I have examined the mouth-parts of *Paraphoxus spinosus* and find that the first maxilla has a two-jointed palp, so this character, together with the strongly expanded fourth joint of peraeopods 3 and 4, places it in the genus *Pontharpinia*. *P. epistoma* can be distinguished from *P. spinosa* by the more expanded sixth joint of the gnathopods and the less oblique palms. In *P. epistoma* the serrations on the rear margin of the second joint of the fifth peraeopod are very prominent, while in *P. spinosa* they are scarcely perceptible. In *P. epistoma* the lower margin of the third pleon segment is convex and bears marginal spines, but in *P. spinosus* this margin is straight or slightly concave and is without spines.

Stebbing, in his diagnosis of the family Phoxocephalidae (Das Tierreich, I. Gammaridea, p. 133) says, "epistome not projecting," but *P. epistoma* has a well-developed forward-projecting epistome, fig. 1 *h*.

There are specimens of *Pontharpinia epistoma* in the U. S. National Museum collection from Isles of Shoals, New Hampshire; Narragansett Bay, Rhode Island; Block Island, Rhode Island; Long Island Sound, and Gardiner's Bay, Long Island; off Martha's Vineyard, Massachusetts; off Broadkill, Delaware; *Albatross* station 2312, off Charleston, South Carolina; and west end of Skull Creek, South Carolina.

Gammarus (Marinogammarus) greenfieldi, n. sp. Fig. 2

Diagnosis.—The corners of the side lobes of head rounding. The lower hind corner of the second joint of peraeopods 3–5 forming a prominent angle which is rounding in peraeopod 3 and square in 4 and 5. Third metasome segment with lower hind angle square and not produced. Uropod 3 with inner ramus well developed and nearly half the length of the outer which is one-jointed and very setose. Telson bearing a conspicuous group of spines on lateral margins.

Male.—Head about as long as the first plus one-half of the second mesosome segment; side-lobes not much protruding, with upper and lower corners rounding. Eye reniform, rather long and narrow, black. Antenna 1 longer than 2; first joint about one-fourth longer than second, which is nearly twice as long as third; flagellum composed of about forty joints. Antenna 2, fourth joint slightly shorter than fifth; flagellum about equal in length to the peduncle; upper and lower margins of peduncle and flagellum furnished with groups of setae, a few of which are sparsely plumose.

Upper lip evenly convex on lower margin, and lateral lobe on right side rather prominent. Right mandible, molar prominent and bearing a seta on hind margin; cutting-edge narrow and bearing three teeth; accessory plate with double serrate cutting edge; five spines in spine-row; second joint of palp longest and bearing spines on outer edge; third joint about three-fourths as long as second and bearing a comb of very fine spines on outer margin, and a group of spines on inner and outer surface. Maxilla 1, right, inner plate with lateral margin spinose throughout; outer plate bearing eleven serrate spine-teeth; palp with the obliquely truncate distal margin bearing five short teeth and two setae. Maxilla 2, outer plate with distal spines only; inner plate with spines on inner margin and apex, and an oblique row of plumose spines near inner margin. Lower lip with inner lobes

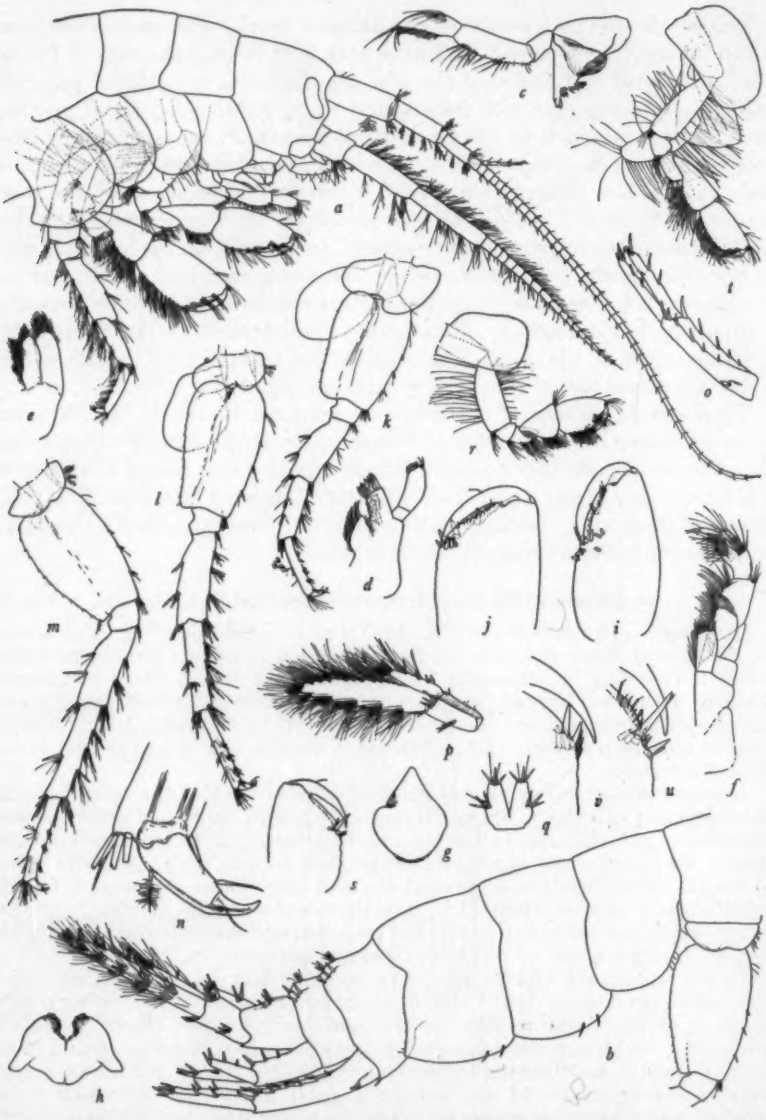


Fig. 2.—*Gammarus* (*Marinogammarus*) *greenfieldi*, new species, male. *a*, Anterior end; *b*, posterior end; *c*, mandible; *d*, maxilla 1; *e*, maxilla 2; *f*, maxilliped; *g*, *h*, upper and lower lips; *i*, *j*, gnathopods 1 and 2, inner side, showing the spine arrangement; *k*, *l*, *m*, peraeopods 3, 4, and 5; *n*, end of peraeopod 5; *o*, uropod 1; *p*, uropod 3; *q*, telson. Female. *r*, *s*, gnathopod 1; *t*, gnathopod 2; *u*, *v*, gnathopods 1 and 2, showing spine arrangement.

not perceptible. Maxilliped with inner plate reaching to about the middle of first joint of palp, armed distally with three spine-teeth and a row of spines which is continued down the inner margin; outer plate reaching to about the middle of the second joint of the palp, armed distally with long, curved spines and along the upper half of the inner edge with spine-teeth; palp well developed, outer margin of third joint produced into a short lobe whose inner margin extends obliquely down the inside of the joint and is furnished with a row of long setae; dactyl well developed and bearing a sharp nail at the base of which is a short setule.

Side-plates 1–3 deeper than broad, lower margin broadly rounding, and bearing a spinule at the junction with the hind margin; side-plate 4 as broad as deep, rear margin excavate, rear lobe without spinules; side-plates 5 and 6 with shallow front lobe. Gnathopod 1, fifth joint four-fifths as long as sixth, sixth joint with palm very oblique and passing imperceptibly into the hind margin, but defined by one long and one short spine against which the dactyl closes, a stout spine in center of palm, and several short, blunt spines, some of which are curved, situated on inside of joint in the vicinity of the defining spines; dactyl curved, not fitting palm, but apex only resting against palm. Gnathopod 2 larger than gnathopod 1, fifth joint three-fourths as long and not as wide as sixth, sixth joint widest distally, palm oblique and passing into the hind margin by a rounding curve, but defined by a long spine just beyond which is a shorter one, a stout spine on the outside at the center of the palm and another on the outside near the defining spine, three spines on inside opposite the defining spine.

Peraeopods 1 and 2 about equal in length; dactyls rather short and stout, and bearing a well-defined nail, inside margin bearing a seta just before the nail, and the nail bearing a seta on the outside at its base. Peraeopods 3–5 increasing in length consecutively, though 5 is only slightly longer than 4, second joints moderately expanded with lower hind corner forming a decided angle, which is rounding in peraeopod 3 and square in 4 and 5; dactyls like those of peraeopods 1 and 2 except that the seta at the base of the nail is on the inside, owing to the turning forward of the limb.

Metasome segments 2 and 3 with lower hind corner quadrate, not produced, lower margin with two spines, but frequently with only one or none at all. Urosome segments 1 and 2 very slightly raised dorsally. The dorsal spine arrangement of the ural segments is quite variable, but the most frequent arrangement appears to be: segment 1, a pair of spines on either side of the median line near the center and one spine on either side of the median line at the rear margin, and three lateral spines obliquely placed on either side; segment 2, a pair of spines on either side of the median line near the center, one spine centrally placed on rear margin and three lateral spines obliquely placed on either side; segment 3, one spine on either side of the median line near rear margin and two lateral spines on either side, no rear marginal spines. Segment 1 has also a spine at the lower lateral corner at the base of uropod 1.

Uropod 1 extending farther back than 2; peduncle, besides the upper marginal and distal spines, has a prominent spine at the lower margin near its base; rami subequal and about two-thirds the length of the peduncle. Uropod 2, peduncle with three or four spines on upper, outer margin, inner ramus longer than outer and about equal in length to the peduncle. Uropod 3 extending much beyond 1 and 2; outer ramus about two and one-half times the length of the peduncle and consisting of only one joint; inner ramus very nearly one-half the length of the outer; outer ramus bearing groups of

spines and setae on outer and inner margins and apex, but the spines on inner margin confined to the upper half; apex bearing four spines; inner ramus bearing spines and setae only on the inner margin and apex. All the setae of uropod 3 are simple and not plumose. Telson as broad as long, cleft nearly to base and reaching to about the end of the peduncle of uropod 3, a group of three spines at the center of the lateral margins and three spines and a few setae on the apex of each lobe. Length, 19 mm.

Type.—A male collected by Mr. Ray Greenfield from a small pool at Pebbly Beach, near Gloucester, Massachusetts, June 20, 1929. U. S. Nat. Mus. no. 75670.

Female.—Like the male in general, but smalier, Gnathopod 1 with fifth and sixth joints shorter than in the male, palm oblique, passing into the hind margin by a rounding curve, and defined on the outside by a spine beyond which are two smaller spines; on the inside, opposite the longer defining spine, is a spine at the base of which are two smaller ones. Gnathopod 2 slenderer than in the male; fifth joint as long as or a little longer than sixth; sixth joint widest in the middle, at which point it is as wide as the fifth, palm less oblique than in the male, evenly convex and passing into the hind margin by a rounding curve, defined by a spine beyond which is a shorter spine and several slender spinules, a pair of spines on inside of palm opposite the shorter outer spine, no spine in center of palm. Length, 15 mm.

This species belongs to the new subgenus *Marinogammarus*, recently created by Dr. A. Schellenberg.[2] This subgenus contained only two species, *G. marinus*, known from Europe as far north as the White Sea, British Isles, Faröe Islands, and the northeast coast of the United States, and *G. locustoides*, known from the northwest coast of North America and the northeast coast of Asia. The present species differs from the other two by the absence of the second joint to the outer ramus of uropod 3, and by the presence of a very well defined lower anterior angle to the second joint of peraeopods 3–5. In *G. marinus* the outer ramus of uropod 3 possesses a very well developed second joint, and in *G. locustoides* the second joint is very small and inconspicuous, but in *G. greenfieldi* the second joint is entirely absent.

Mr. Ray Greenfield, while visiting the Massachusetts coast near Gloucester during the summer of 1929, found this amphipod to be a very abundant inhabitant of the intertidal zone and rock pools left by the receding tide. He made a very fine collection, including individuals of all sizes, for the the National Museum, and I am therefore naming this species for him.

There are in the National Museum collection specimens of *Gammarus greenfieldi* from Frenchman's Bay, and Heron Island, Lincoln County, Maine; Rye Beach and Isles of Shoals, New Hampshire; Gloucester and Cohasset, Massachusetts.

[2] Zoologischer Anzeiger, Bd. 117, heft 11/12, p. 270. 1937.

MAMMALOGY.—*New pocket gophers of the genus* Thomomys *from Arizona and Utah.*[1] E. A. GOLDMAN, Bureau of Biological Survey.

Resumed studies of the pocket gophers of the genus *Thomomys* in Arizona have led to the decision that several additional subspecies of widely dispersed, and extremely plastic, *Thomomys bottae* group must be recognized. It has also become evident that several well-marked geographic races have hitherto been included in the territory assigned to *Thomomys fossor*, west of the Colorado River in Arizona and Utah. These conclusions are based on studies of numerous specimens recently acquired by the Bureau of Biological Survey, supplemented by the examination of pertinent material in other museums, thus affording a clearer concept of many complex regional relationships. Many gaps in our knowledge of the forms of the genus in Arizona alone still remain, however, to be filled by coördinated field and laboratory investigations.

I am especially indebted to Laurence M. Huey, Curator of Mammals and Birds, Natural History Museum, San Diego, California, and to Dr. Joseph Grinnell, Director, Museum of Vertebrate Zoology, Berkeley, California, for the privilege of reviewing material in their charge. Mr. Huey has conducted several expeditions to Arizona; and under direction of Dr. Grinnell, extensive mammal collections, including pocket gophers, were made by Miss Annie M. Alexander and Dr. Seth B. Benson in many parts of the State.

Thomomys fossor kaibabensis, subsp. nov.

Kaibab Pocket Gopher

Type.—From DeMotte Park, Kaibab Plateau, Coconino County, Arizona (altitude 9,000 feet). No. 262891, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Luther C. Goldman, September 10, 1937. Original number 443.

Distribution.—Apparently restricted to the Kaibab Plateau.

General characters.—A large, comparatively light-colored subspecies of the *Thomomys talpoides-fossor-quadratus* group. Resembling typical *Thomomys fossor* of southwestern Colorado, but larger, color less rufescent, near sayal brown instead of mikado brownish; skull differing in detail, especially the smaller interparietal. Similar to *Thomomys uinta* of the Uinta Mountains, northern Utah, in color over dorsum, but sides of body and under parts more buffy, less grayish; skull larger, more elongated and presenting other differential features. Not very unlike *Thomomys quadratus fisheri* of northeastern California and northern Nevada, but very much larger and color darker, the dorsum more profusely mixed with black; cranial details distinctive.

[1] Received April 30, 1938.

Color.—Type (worn pelage): Upper parts near "sayal brown" (Ridgway, 1912), moderately mixed with black, paling gradually to "pinkish buff" along lower part of flanks and on forearms and thighs; anterior part of body irregularly flecked with white, a character appearing sporadically in the group and with little or no taxonomic significance; under parts overlaid with pinkish buff, the dark under color showing through; muzzle blackish; ears black, flecked with white; postauricular areas deep black; feet white; tail brownish above on basal two-thirds, white below, becoming white all around toward tip.

Skull.—Similar to that of *fossor* but larger; zygomata more widely spreading; interparietal smaller; posterior border of palate more extended and shelf-like; auditory bullae larger; molariform teeth similar, but upper incisors broader, less recurved. Somewhat like that of *uinta*, but larger, less flattened, more convex in upper outline; rostrum and nasals longer, the nasals usually truncate or slightly rounded instead of deeply emarginate posteriorly; premaxillae less prolonged beyond nasals posteriorly; interparietal relatively smaller; posterior border of palate more extended and shelf-like; auditory bullae much larger; molariform teeth similar; upper incisors broader, less procumbent. Somewhat similar in general form to that of *fisheri*, but contrasting strongly in much greater size; premaxillae relatively narrower, less prolonged beyond ends of nasals posteriorly; palatal shelves more extended posteriorly; auditory bullae larger; dentition similar.

Measurements.—Type: Total length, 238 mm; tail vertebrae, 58; hind foot, 31. An adult male topotype: 225; 64; 31. Average of four adult female topotypes: 223 (215–230); 59 (57–64); 30 (29–31). *Skull* (type [♂], and an adult female topotype): Occipitonasal length, 41.7, 39.5; zygomatic breadth, 25.1, 22.9; breadth across squamosals (over mastoids), 20.6, 19.5; interorbital constriction, 5.7, 6.4; length of nasals, 16.6 15.2; interparietal, 7×5.6, 8.9×5.3; maxillary toothrow (alveoli), 7.7, 7.6.

Remarks.—General comparisons indicate that numerous forms, including *fossor* and *quadratus*, differ only subspecifically from *talpoides*, but a new group alignment should be based on more complete studies than I have made. *Thomomys fossor* has, hitherto, been accorded an extensive range west of the Colorado and Green rivers in southern Utah and northwestern Arizona. Additional material, recently collected, now indicates that specimens from the region mentioned must be assigned to other subspecies. *T. f. kaibabensis* is readily distinguished from *fossor* by the combination of large size and well-marked cranial features, but exhibits a similarity in pattern of characters indicating close alliance.

Specimens examined.—Total number, 23, all from Kaibab Plateau, Arizona, as follows: Bright Angel Spring, 3; DeMotte Park (type locality), 18; Greenland Spring, 1; Jacob Lake, 1.

Thomomys fossor parowanensis, subsp. nov.

Parowan Mountains Pocket Gopher

Type.—From Brian Head, Parowan Mountains, Iron County, Utah (altitude 11,000 feet). No. 158072, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by W. H. Osgood, September 8, 1908. Original number 3483.

Distribution.—High mountains of southwestern Utah.

General characters.—Closely resembling *Thomomys fossor kaibabensis* of northwestern Arizona externally; color about the same, but decidedly smaller, the difference in size most obvious in the skull; cranial details different. Similar to *Thomomys uinta* of the Uinta Mountains in size, and in color over dorsum, but sides of body more buffy, less grayish; rostrum much longer. Much larger and darker than *Thomomys quadratus fisheri* of northeastern California; skull differing in proportions.

Color.—Type (acquiring winter pelage): Upper parts in general near "sayal brown" (Ridgway, 1912), brightest and approaching "cinnamon" on top of head, moderately mixed with black, paling gradually to "pinkish buff" along lower part of flanks and on forearms and thighs; under parts evenly overlaid with pinkish buff; muzzle blackish; ears and postauricular areas deep black; feet white; tail light brownish above and below on basal two-thirds, becoming white all around toward tip.

Skull.—Very similar in general to that of *kaibabensis* in general form, but distinctly smaller; rostrum and nasals long, the nasals truncate or slightly rounded posteriorly as in *kaibabensis;* auditory bullae relatively smaller; maloriform teeth similar, but incisors narrower. Similar in size to that of *uinta,* but rostrum and nasals longer, the nasals truncate or slightly rounded posteriorly, instead of deeply emarginate as usual in *unita;* premaxillae less extended posteriorly beyond ends of nasals; interparietal smaller; dentition lighter, the upper incisors curved more directly downward (slightly procumbent in *uinta*). Compared with that of *T. q. fisheri* the skull is larger, with longer rostrum and nasals; auditory bullae relatively larger; dentition similar, but molariform teeth comparatively light.

Measurements.—Type: Total length, 228 mm; tail vertebrae, 64; hind foot, 29. An adult male topotype: 228; 74; 31. An adult female topotype: 206; 58; 29. *Skull* (type [♂] and an adult female topotype): Occipitonasal length, 38.1, 36.5; zygomatic breadth, 21, 19.7; breadth across squamosals (over mastoids), 18.4, 17; interorbital constriction, 5.8, 5.7; length of nasals, 14.5, 12.8; interparietal, 7.8×4.8, 7.8×4.9; maxillary toothrow (alveoli), 7.7, 6.8.

Remarks.—Thomomys fossor parowanensis is more closely allied to *kaibabensis* than to any other known form, but the smaller size and cranial features pointed out are separative. It requires no close comparison with *fossor, uinta,* or *fisheri.*

Specimens examined.—Total number, 16, all from Utah, as follows: Beaver (or Tushar) Mountains, 10; Buckskin Valley, Iron County, 1; Panguitch Lake, 1; Parowan Mountains (type locality), 4.

Thomomys fossor moorei, subsp. nov.

Type.—From one mile south of Fairview, Sanpete County, Utah (altitude 6,000 feet). No. 248222, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by A. W. Moore, February 19, 1928. X-catalog number 24799.

Distribution.—San Pete Valley and adjoining mountains of central Utah.

General characters.—Approaching *Thomomys uinta* of the Uinta Mountains; size similar but color paler, the upper parts less mixed with black; skull differing in greater length of rostrum and other features. Similar in size to *Thomomys fossor parowanensis* of the Parowan Mountains, but color

brighter, more rufescent, the dorsum less modified by black; skull broader, with nasals deeply emarginate posteriorly.

Color.—Type (winter pelage): Upper parts in general between "cinnamon" and "sayal brown" (Ridgway, 1912), the top of head and back finely overlaid with dusky hairs that scarcely alter the general tone; flanks, forearms, thighs, and under parts "pale pinkish buff"; muzzle brownish, except a small white patch on top of nose; chin whitish; ears and postauricular patches deep black; feet white; tail very light brownish above, white below. The summer pelage is distinctly darker, near "mikado brown," slightly mixed with black.

Skull.—Most closely resembling that of *uinta*, but rostrum and nasals longer, the nasals deeply emarginate posteriorly as in *uinta;* braincase slightly broader; interparietal smaller; dentition usually lighter, the upper incisors longer and curving more directly downward (curving slightly forward in *uinta*). Compared with that of *parowanensis* the skull is straighter in upper profile, more depressed across anterior roots of zygomata; nasals deeply emarginate instead of rounded posteriorly; upper incisors longer.

Measurements.—Type: Total length, 220 mm; tail vertebrae, 67; hind foot, 29. Average of five adult male topotypes: 217 (203–236); 64 (52–72); 29 (28–31). Average of five adult female topotypes: 205 (198–207); 60 (55–64); 26 (25–27). *Skull* (type and an adult female topotype): Occipitonasal length, 37.7, 35.4; zygomatic breadth, 22, 22.5; breadth across squamosals (over mastoids), 18.6, 18.8; interorbital constriction, 6.5, 6.5; length of nasals, 14.6, 12.6; interparietal, 5.9×3.9, 6.2×3.9; maxillary toothrow (alveoli), 7.3, 7.2.

Remarks.—Thomomys fossor moorei is more closely allied to *T. uinta* than to any of the other forms of the group but, as shown by cranial details, it tends to bridge a rather wide gap between *uinta* and *parowanensis*. Specimens from 10,000 feet altitude near Ephraim are darker in color, but agree closely in cranial details, and it seems best to refer them to *moorei*. This new form is based upon a fine series of specimens taken at the type locality by A. W. Moore for whom it is named.

Specimens examined.—Total number, 32, all from central Utah, as follows: Ephraim, 5; Fairview (type locality), 27.

Thomomys fossor levis, subsp. nov.

Fish Lake Plateau Pocket Gopher

Type.—From Seven Mile Flat, five miles north of Fish Lake, Fish Lake Plateau, Sevier County, Utah (altitude 10,000 feet). No. 158079, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by W. H. Osgood, October 1, 1908. Original number 3616.

Distribution.—Known only from the type locality.

General characters.—Similar in general to *Thomomys fossor parowanensis* of the Parowan Mountains; size and color about the same; skull differing in detail, notably the reduction of the interparietal in antero-posterior dimension. Similar in size to *T. f. moorei* of central Utah, but color darker, upper parts more mixed with black and under parts a deeper buffy tone in winter pelage; cranial features, especially the shortness of the interparietal and the rounded posterior ends of the nasals, distinctive.

Color.—Type (acquiring winter pelage): Upper parts near "sayal brown" (Ridgway, 1912), deepest on top of head, moderately mixed with black, paling gradually to "pinkish buff" along lower part of flanks and on forearms and thighs; under parts overlaid with pinkish buff, except a patch on chin which is pure white to roots of hairs; muzzle blackish; ears and postauricular spots deep black; feet white; tail light brownish on basal half above and below, white all around thence to tip.

Skull.—Rather closely resembling that of *parowanensis*, but interparietal less extended antero-posteriorly, laterally pointed elliptical instead of triangular, there being little trace of the anterior angle usually well developed in the group, ascending branches of premaxillae usually less projecting beyond posterior ends of nasals; dentition similar, but upper incisors shorter. Compared with that of *moorei* the skull is similar in general size, but more convex in upper outline and it differs in form of interparietal as from *parowanensis;* nasals rounded posteriorly, instead of deeply emarginate; zygomata less widely spreading; ascending branches of premaxillae less prolonged beyond posterior ends of nasals; upper incisors shorter, more strongly recurved.

Measurements.—Type: Total length, 208 mm; tail vertebrae, 55; hind foot, 28. *Skull* (type): Occipitonasal length, 35.7; zygomatic breadth, 20; breadth across squamosals (over mastoids), 18.7; interorbital constriction, 6.1; length of nasals, 13.3; interparietal, 8.2×3.1; maxillary toothrow (alveoli), 7.

Remarks.—Thomomys fossor levis is closely allied to *T. f. parowanensis*, but the peculiar form of the interparietal readily separates it from any of the subspecies of the group.

Specimens examined.—Four, all from the type locality.

Thomomys bottae nicholi, subsp. nov.

Shivwits Plateau Pocket Gopher

Type.—From 20 miles south of Wolf Hole (road to Parashouts), Shivwits Plateau, Mohave County, Arizona (altitude 5,000 feet). No. 262864, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Luther C. Goldman, August 6, 1937. Original number 363.

Distribution.—Shivwits Plateau region, on the terrace between the Hurricane Ledge and Grand Wash Cliffs, north of the Grand Canyon, northwestern Arizona; north to St. George, Utah.

General characters.—A light buff-colored subspecies of medium size. Closely allied to *Thomomys bottae trumbullensis* of the neighboring Mount Trumbull lava area, but much paler buff, the dorsum much less mixed with black; cranial characters nearly identical. Similar in general to *Thomomys bottae virgineus* of the Virgin River Valley below the break through the Beaverdam Mountains, but usually somewhat darker, and cranial details, notably the more widely and evenly spreading zygomata distinctive. Differing from *Thomomys bottae planirostris* of Zion National Park, Utah, in smaller size, less tawny coloration, and less massive skull.

Color.—Type (acquiring fresh pelage): Upper parts near "cinnamon buff" (Ridgway, 1912), thinly mixed with black on head and over back, paling gradually to "pinkish buff" on flanks, forearms and thighs; under parts overlaid with "pale pinkish buff," palest on inguinal region, varying to near

"cinnamon buff" on throat and chest; muzzle blackish; feet white; tail thinly clothed all around with whitish hairs. In some other specimens the tail is cinnamon buffy on basal half above.

Skull.—Very closely resembling that of *trumbullensis*. Similar in size to that of *virgineus*, but frontal region broader; zygomata more widely spreading, the sides more nearly parallel, and the jugals not distinctly bowed inward as in *virgineus;* dentition about the same. Compared with that of *planirostris* the skull is less massive; rostrum and nasals decidedly narrower; dentition lighter.

Measurements.—Type: Total length, 228 mm: tail vertebrae, 67; hind foot, 29. Two adult male topotypes: 229, 208; 65, 59; 27.5, 28. *Skull* (type): Occipitonasal length, 39.5; zygomatic breadth, 23.9; width across squamosals (over mastoids), 29.7; interorbital constriction, 6.4; length of nasals, 14; interparietal, 5.9×4.4; maxillary toothrow (alveoli). 7.5.

Remarks.—Thomomys bottae nicholi occupies the broad terrace along the base of the Hurricane Ledge, extending westward toward the top of the Grand Wash Cliffs. Both of these topographic features mark great "fault" lines extending north and south across the Grand Canyon.

T. b. nicholi agrees closely in cranial characters with *trumbullensis* which inhabits the lava area surrounding Mount Trumbull, on the higher plateau, but is readily distinguished by paler coloration. Specimens from St. George, Utah, are more tawny in tone and suggest gradation toward *planirostris.*

This new subspecies is dedicated to Andrew A. Nichol of the University of Arizona, botanist, zoologist, master workman in Nature's laboratory, who assisted in the collection of specimens.

Specimens examined.—Total number, 19, as follows:

Arizona: Diamond Butte (3 miles northwest), 1; Wolf Hole, 6 (20 miles south, 4; 6 miles north, 2).

Utah: St. George, 12.

Thomomys bottae alienus, subsp. nov.

Upper Gila Valley Pocket Gopher

Type.—From Mammoth, San Pedro River, Pinal County, Arizona (altitude 2,400 feet). No. 261926, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by E. A. Goldman, November 4, 1936. Original number 23746.

Distribution.—San Pedro River Valley, and upper part of Gila River Valley in southeastern Arizona and southwestern New Mexico.

General characters.—A large, rich rufescent subspecies of the *Thomomys bottae* group; mammae, pectoral two pairs, inguinal two pairs. Similar in general to *Thomomys bottae cervinus* of the Salt River Valley, but smaller; upper parts near "cinnamon" (Ridgway, 1912), instead of "vinaceous buff"; skull smaller, less angular. Approaching *Thomomys bottae opulentus* of the Rio Grande Valley, southern New Mexico, in size and coloration; cranial characters, especially the more slender rostrum and less recurved upper incisors, distinctive. Similar to *Thomomys bottae toltecus* of the Casas Grandes River Valley, northwestern Chihuahua, but color more vivid; contrasting also in cranial details notably the lower braincase and less procumbent upper incisors. Decidedly larger, less distinctly tawny than *Thomomys bottae*

mutabilis, of the Verde River Valley. Differing from *Thomomys bottae extenuatus* of the Sulphur Springs Valley region, mainly in decidedly larger size.

Color.—*Type* (acquiring winter pelage): Upper parts near "cinnamon" (Ridgway, 1912), moderately mixed with black over top of head and back, becoming lighter, the dark hairs thinning out, and near "cinnamon buff" on flanks, forearms and thighs; under parts overlaid with "pinkish buff," varying to cinnamon buff on the median area from throat to chest; muzzle blackish; feet white; tail blackish above, on basal three-fourths, becoming whitish below, and white all around near tip. Color varying over dorsum in other specimens from "cinnamon" heavily mixed with black to nearly clear "tawny."

Skull.—Similar to that of *cervinus*, but smaller, less angular; auditory bullae smaller, less inflated; dentition lighter. Resembling that of *opulentus*, but flatter, less convex in upper outline, the nasals less depressed anteriorly; rostrum narrower; bullae usually smaller; upper incisors narrower less recurved. Compared with that of *toltecus* the skull is similar in size, but braincase broader, lower, and flatter; supraoccipital region more deeply concave; upper incisors less procumbent, curving nearly directly downward. Not very unlike that of *mutabilis*, but considerably larger and heavier. Differing from that of *extenuatus* mainly in larger size, and less inflated auditory bullae.

Measurements.—*Type:* Total length, 247 mm; tail vertebrae, 75; hind foot, 33. Average of four adult male topotypes: 240 (230–254); 68 (58–80); 32 (30–33.5). Average of four adult female topotypes: 212 (207–218); 58 (57–59); 28 (27.5–28.5). *Skull* (type [♂] and an adult female topotype): Occipitonasal length, 41.4, 37.9; zygomatic breadth, 27, 24.8; width across squamosals (over mastoids), 21.4, 20.2; interorbital constriction, 6.9, 7.3; length of nasals, 14.2, 13.5; maxillary toothrow (alveoli), 8.3, 8.1.

Remarks.—*Thomomys bottae alienus* appears to be restricted to the valleys of the upper part of the Gila River and some of its affluents. It undoubtedly intergrades with obviously related forms inhabiting the higher neighboring areas. In specimens from Duncan, Arizona, the upper incisors tend to project forward and suggest gradation toward *toltecus*, but in cranial details, and in coloration agree closely with *alienus*. .

Specimens examined.—Total number, 52, as follows:

Arizona: Duncan, 9; Mammoth (type locality), 9; Safford, 31.

New Mexico: Redrock, 3.

Thomomys bottae parvulus, subsp. nov.

Intermountain Pocket Gopher

Type.—From pass between Santa Catalina and Rincon Mountains, Pima County, Arizona (altitude 4,500 feet). No. 262813, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Luther C. Goldman, June 5, 1937. Original number 213.

Distribution.—Known only from the vicinity of the type locality.

General characters.—A very small, tawny subspecies; mammae, pectoral two pairs, inguinal two pairs. Allied to *Thomomys bottae catalinae* of the upper slopes of the closely adjoining Santa Catalina Mountains, but much smaller, and color lighter, more inclining toward tawny. Somewhat similar to *T. b. extenuatus* of the Sulphur Springs Valley, and to *T. b. modicus* of the

lower elevations to the west in color, but contrasting strongly in diminutive size with both.

Color.—Type (summer pelage): Upper parts near "cinnamon" (Ridgway, 1912), darkened on forehead and median line of rump by black-tipped hairs, paling through "pinkish cinnamon" to "cinnamon buff" along lower part of flanks, and on forearms and thighs; under parts overlaid with cinnamon buff; muzzle blackish; ears and small postauricular patches deep black; feet white; tail light brownish above, whitish below. Upper parts varying in other specimens from a more profuse admixture of black to nearly pure cinnamon. In one individual most of the body is irregularly flecked with white.

Skull.—Similar in general to that of *catalinae*, but much smaller; rostrum and nasals relatively shorter. Not very unlike those of *extenuatus* and *modicus* in general form, but so much smaller that close comparison is not required.

Measurements.—Type: Total length, 200 mm; tail vertebrae, 45; hind foot, 26. Two adult male topotypes: 203, 211; 60, 57; 27, 25. Two adult female topotypes: 190, 188; 56, 55; 25, 25. *Skull* (type [♂] and an adult female topotype): Occipitonasal length, 35.9, 34.1; zygomatic breadth, 22.9, 20.8; width across squamosals (over mastoids), 18.4, 17.4; interorbital constriction, 6.3. 6.3, length of nasals, 11.9, 11.1; maxillary toothrow (alveoli), 7, 6.8.

Remarks.—Thomomys bottae parvulus is a diminutive form apparently restricted in range to gravelly pockets in the granitic formation in the pass between the Santa Catalina and Rincon Mountains. Rock exposures in the vicinity may be effective barriers limiting distribution. Close alliance with the neighboring forms is evident, but the departure in size is remarkable.

Specimens examined.—Thirteen, all from the type locality.

Thomomys bottae hueyi, subsp. nov.

Rincon Mountains Pocket Gopher

Type.—From Spud Rock Ranger Station, Rincon Mountains, Pima County, Arizona (altitude 7,400 feet). No. 10088, ♂ adult, skin and skull collection San Diego Society of Natural History; collected by Laurence M. Huey, June 17, 1932.

Distribution.—Known only from the upper slopes (7,400 to 7,900 feet) of the Rincon Mountain.

General characters.—Closely allied to *Thomomys bottae catalinae*, of the adjoining Santa Catalina Mountains; size and cranial features about the same; color decidedly paler, the upper parts less profusely mixed with black and the under parts a lighter buff tone. Similar in general to *Thomomys bottae parvulus* of the pass, only a few miles away, between the Rincon Mountains and the Santa Catalina Mountains, but decidedly larger and usually darker in color. Very similar in color to *Thomomys bottae grahamensis* of the Graham Mountains; differing in slight but appreciable cranial details, including the narrower interorbital region. Color less inclined toward tawny, and skull less massive than in *Thomomys bottae extenuatus* of the Sulphur Springs Valley.

Color.—Type (summer pelage): Upper parts near "cinnamon" (Ridgway, 1912), thinly and inconspicuously mixed with black, paling gradually to "cinnamon buff" along lower part of sides, and on forearms and thighs; under parts overlaid with cinnamon buff: muzzle blackish; ears and post-

auricular patches black; feet white; tail thinly clothed with dull whitish hairs above and below. Upper parts varying in other specimens to a heavier admixture of black.

Skull.—About as in *catalinae*. Distinctly larger than that of *parvulus*. Very similar to that of *grahamensis*, but frontals narrower, supraorbital region rising less steeply, more inclined forward, instead of bulging posteriorly over foramen magnum. Compared with *extenuatus* the skull is slenderer in proportions; braincase narrower; auditory bullae smaller.

Measurements.—Type: Total length, 215 mm; tail vertebrae, 64; hind foot, 27. Two adult male topotypes: 220, 220; 62, 66; 30, 29. Two adult female topotypes: 198, 196; 60, 60; 26, 27. *Skull* (type [♂] and an adult female topotype): Occipitonasal length, 37, 38; zygomatic breadth, 22.5, 22.9; width across squamosals (over mastoids), 18.7, 23; interorbital constriction, 6.5, 6.4; length of nasals, 13.4, 13.6; maxillary toothrow (alveoli), 7.7, 7.9.

Remarks.—Thomomys bottae hueyi is not very unlike *catalinae*, but appears to be isolated by the interposed range of *parvulus*, and the difference in color is distinctive. It is named for the collector of the fine series of specimens, Laurence M. Huey, curator of mammals and birds, Natural History Museum, San Diego, in recognition of his important contributions to knowledge of the fauna of the Southwest.

Specimens examined.—Total number, 37, all from the Rincon Mountains, Arizona, as follows: Spud Rock Ranger Station (7,400 feet), 20; Manning Camp (7,900 feet), 17.

Thomomys bottae patulus, subsp. nov.

Hassayampa Valley Pocket Gopher

Type.—From bottomland along Hassayampa River, two miles below Wickenburg, Maricopa County, Arizona (altitude, 2,000 feet). No. 262899, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Luther C. Goldman, September 16, 1937. Original number 460.

Distribution.—Known only from the type locality, but probably has an extensive range along the valley of the Hassayampa River.

General characters.—A large cinnamon or cinnamon buff subspecies; mammae, pectoral two pairs, inguinal two pairs. Somewhat similar to *Thomomys bottae cervinus* of the Salt River Valley, but smaller; upper parts more vivid in color, near "cinnamon" or "cinnamon buff" (Ridgway, 1912), instead of "vinaceous buff" or "avellaneous"; skull less angular. Similar to *Thomomys bottae mutabilis* of the Verde River Valley, and *Thomomys bottae desitus* of the Big Sandy River Valley, but size larger and color much paler than either. Similar in size to *Thomomys harquahalae* of the Ranegras Plain to the westward, but color richer buff; cranial characters indicating no very close relationship.

Color.—Type (acquiring fresh pelage): Upper parts near "cinnamon" (Ridgway, 1912), mixed with black on top of head, but only slightly darkened by black-tipped hairs over dorsum, passing gradually through "cinnamon buff" to "pinkish buff" along lower part of sides, and on forearms and thighs; under parts overlaid with pinkish buff, varying to near "pinkish

cinnamon" on chest and throat; muzzle blackish; ears encircled with black; feet white; tail light brownish above, dull whitish below.

Skull.—Similar in general to that of *cervinus*, but smaller, less angular, relatively shorter and broader; temporal ridges less upturned; premaxillae less prolonged posteriorly beyond nasals; interparietal relatively shorter and broader; mastoid and auditory bullae smaller, the auditory bullae more rounded anteriorly (somewhat angular or truncated anteriorly in *cervinus*). Resembling that of *mutabilis*, but larger. Compared with that of *desitus* the skull is larger, relatively broader and heavier. Similar in size to *harquahalae*, but zygomata less widely spreading; nasals and frontals less depressed along the median line between posterior ends of premaxillae (tending toward concavity in transverse section in adult males of *harquahalae*); upper incisors more abruptly decurved, instead of strongly procumbent.

Measurements.—Type: Total length, 245 mm; tail vertebrae, 64; hind foot, 30. An adult male and an adult female topotype: 240, 215; 80, 60; 31, 29. *Skull* (type [♂] and an adult female topotype): Occipitonasal length, 40.8, 36.5; zygomatic breadth, 27.4, 23.3; width across squamosals (over mastoids), 22, 18.5; interorbital constriction, 7, 6.8; length of nasals, 14.3, 12.8; maxillary toothrow (alveoli), 8.3, 8.2.

Remarks.—Thomomys bottae patulus may be restricted to the alluvial soil along the Hassayampa River Valley, as the distribution of pocket gophers appears to be discontinuous in the adjoining arid areas. The alliance of this subspecies to the neighboring geographic races is shown, but it differs from all in combination of size, color, and cranial details.

Specimens examined.—Sixteen, all from the type locality.

Thomomys bottae pinalensis, subsp. nov.

Pinal Mountains Pocket Gopher

Type.—From Oak Flat, 5 miles east of Superior, Pinal Mountains, Arizona. No. 245709, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Walter P. Taylor, May 22, 1924. Original number 1667.

Distribution.—Known only from the Pinal Mountains, but may have a wider range in the mountain mass between the Gila and Salt rivers.

General characters.—A very small dark-colored subspecies, with a narrow, weakly developed skull; mammae, pectoral two pairs, inguinal two pairs. Most closely allied to *Thomomys bottae mutabilis* of the adjoining region to the north, but much smaller and darker than usual in that form; skull much smaller, narrower, less massive. Resembling *Thomomys bottae fulvus* of the Mogollon Plateau region in color, but much smaller, and skull presenting about the same differences as from *mutabilis*.

Color.—Type (acquiring fresh pelage): Upper parts near "cinnamon" (Ridgway, 1912), mixed with black, the black tending to become predominant along a narrow median line from top of head to rump, becoming gradually lighter and near "cinnamon-buff" on forearms, flanks, and thighs; under parts thinly overlaid with a mixture of "pinkish-buff" and gray, the darker basal color showing through; muzzle blackish, ears encircled with black; feet white; tail light brownish above, whitish below, becoming white all around at tip.

Skull.—Similar in general to those of *mutabilis* and *fulvus*, but much smaller and relatively narrower and slenderer than either; zygomata more

strongly convergent anteriorly; maxillary arm of zygoma relatively heavy, but jugal more slender; palate very narrow; auditory bullae small, much as in *fulvus*.

Measurements.—Types: Total length, 195 mm; tail vertebrae, 56; hind foot, 24; weight, 81.6 grams. *Skull* (type): Occipitonasal length, 33; zygomatic breadth, 19.7; width across squamosals (over mastoids), 16.9; interorbital constriction, 6.3; length of nasals, 11.5; maxillary toothrow (alveoli), 6.9.

Remarks.—T. b. pinalensis is based on a single specimen exhibiting characters that along with geographic considerations seem to warrant the recognition of a new subspecies. It requires no close comparison with the much larger, "vinaceous buff" or light fawn-colored animal, *Thomomys bottae cervinus*, inhabiting the Salt River Valley not far to the west.

Obituary

GEORGE BIRD GRINNELL, ethnologist, author and explorer, died at his home, 238 E. 15th Street, New York, on April 11, 1938. Dr. Grinnell was born in Brooklyn, N. Y. Sept. 20, 1849. He received the A.B. degree from Yale University in 1870, the Ph.D. in 1880, and in 1921 was awarded the honorary degree of Litt.D. In the summer of 1870 he accompanied Prof. O. C. Marsh of Peabody Museum on his first expedition to the Far West. Two years later Grinnell accompanied the Pawnee Indians on a buffalo hunt and on these and subsequent expeditions he developed his life long interest in the Indians themselves, and in the conservation of western wild life. From 1874 to 1880 he was assistant in osteology at the Peabody Museum. In the summer of 1874 he went as naturalist with Gen. George A. Custer's first expedition to the Black Hills, and the following summer accompanied Col. William Ludlow on his reconnaissance of Yellowstone Park. In 1885 he discovered Grinnell Glacier in Montana, and it was largely due to his long continued efforts that legislation was later enacted for the establishment of Glacier National Park and for the protection of its wild life and that of the Yellowstone Park. In 1895, at the request of the Blackfoot and Fort Belknap Indians, Dr. Grinnell was appointed United States Commissioner to treat with them for the cession of part of their lands. In 1899 he was a member of the Harriman Expedition to Alaska.

With Col. Theodore Roosevelt he was one of the founders of the Boone and Crockett Club, an organization of sportsmen and game conservationists, whose members later organized the New York Zoological Society. As joint editor with Col. Roosevelt of the Boone and Crockett Club publications, and later as editor and owner of the magazine *Forest and Stream*, Dr. Grinnell exercised a wide influence among sportsmen and naturalists. He was active in various conservation organizations, including the American Game Association of which he was a founder and director; he was chairman of the Council on National Parks, Forests and Wild Life, and president of the National Parks Association. In recognition of his efforts in the cause of conservation he was selected in 1925 as one of the recipients of the Roosevelt Gold Medal for Distinguished Service, presented by Roosevelt Memorial Association.

Dr. Grinnell was the author of a number of popular books on Indian life and on the West. His scientific books and papers, dealing mainly with the Cheyenne, Blackfoot, and Pawnee, have provided valuable information on the customs, traditions, and history of those tribes.

Dr. Grinnell was a member of the Anthropological and Biological Societies of Washington, the Washington Academy of Sciences, American Anthropological Association, and the Archeological Institute of America. He was a fellow of the American Association for the Advancement of Science, American Ethnological Society, American Ornithologists Union, American Society of Mammalogists, and the New York Academy of Sciences. He was also a trustee of Hispanic Society of America, the National Association of Audubon Societies and the New York Zoological Society.

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